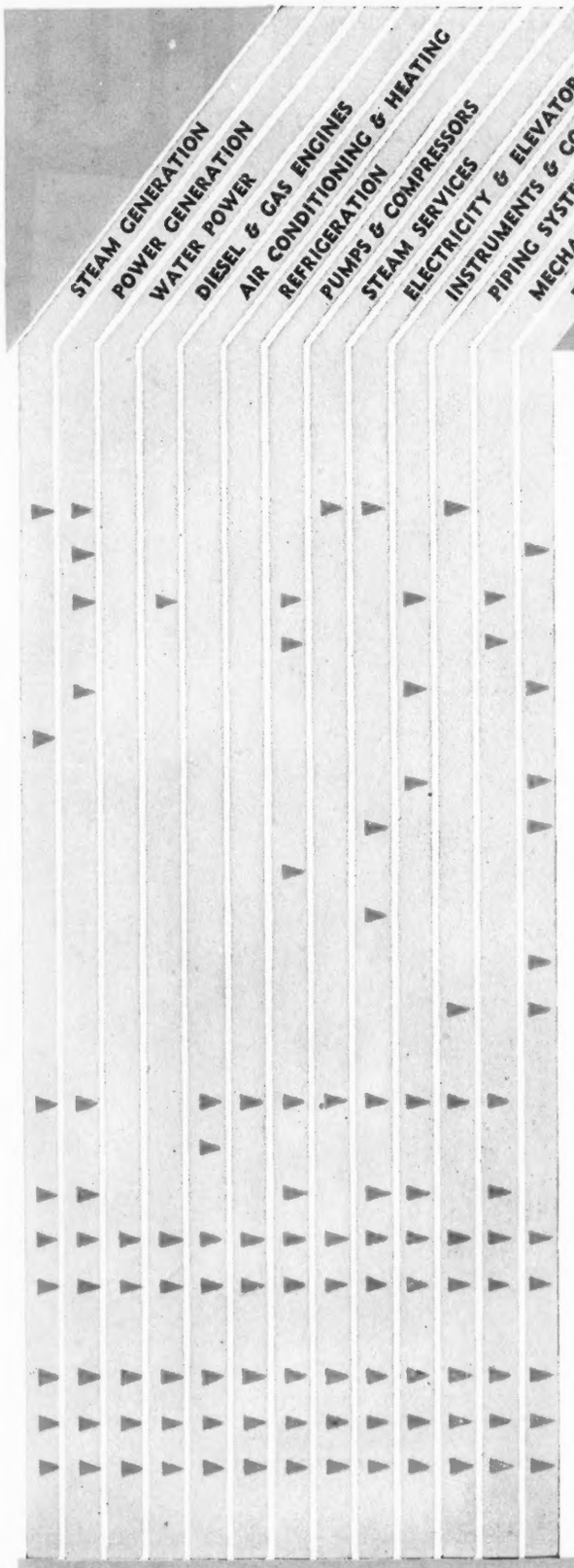

POWER

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APRIL, 1940

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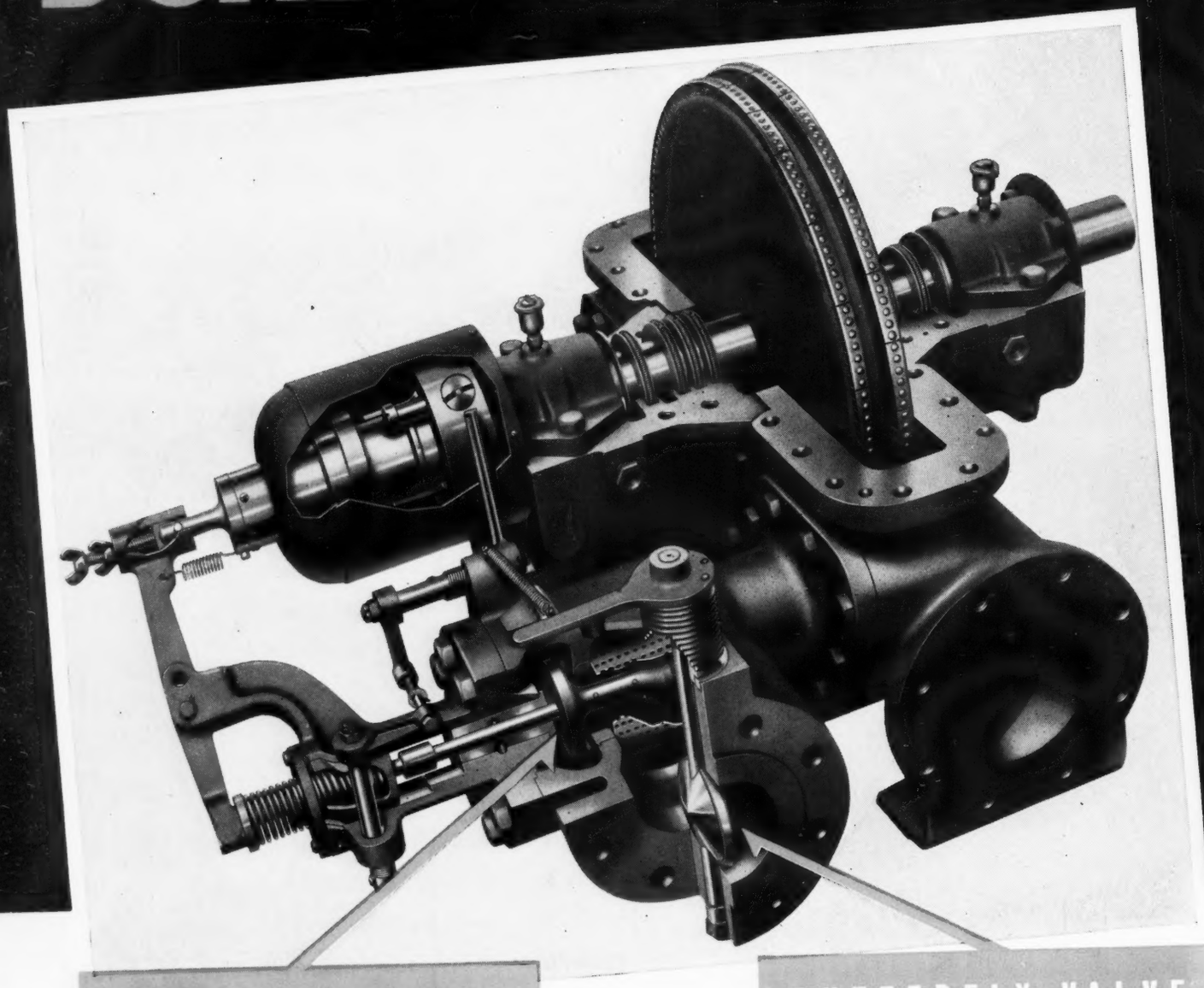
DUAL PROTECTION



GOVERNOR VALVE

trips simultaneously with the butterfly valve in event of overspeeding.

BUTTERFLY VALVE

cuts off steam supply instantly in event of overspeeding—positive acting protection.

A NEW SAFETY *FEATURE*

Westinghouse has for many years successfully employed *single protection*—tripping the governor valve in event of overspeeding. Now comes *Dual Protection* — a further development that gives the greatest possible safety—an additional independent butterfly valve that trips simultaneously with main governor valve — all at no additional price.

The complete line of general purpose turbines includes Single-Stage Turbines — Type C — the standard for mechanical steam drives, 5 to 1500 horsepower.

Also Type M Multi-Stage Turbines—up to 3000 hp.

Westinghouse *Complete*

POWER

Established 1882 PHILIP W SWAIN, Editor

Philosophy of Maintenance

A few weeks ago I spent some hours with a plant manager and his master mechanic, comparing notes on the management of maintenance. I came with a few ideas, left with more, for these men were very close to their plant job.

They knew whereof they spoke and were literally transforming a run-down plant into an ace. The big all-time cleanup was nearly finished and a system of preventive maintenance, closely keyed to the actual working force and plant layout, was taking shape. Here is the maintenance philosophy — their ideas (mostly) in my words:

When you take over a run-down plant you've got a big cleanup on your hands. You've got to renovate the plant and you've got to renovate the maintenance gang. Sloppy maintenance management makes a sloppy plant and a sloppy plant makes sloppy maintenance men.

You'll probably find the gang laboring under the impression that they are a sort of fire department entitled to play pinochle in some cozy corner of the boiler room until the alarm sounds to indicate that something has busted. You've got to cure that — sell the idea of preventing breakdowns.

You can't cure bad habits in a day, so you shuffle the gang around a little to break the old patterns, then tackle an object lesson. You announce that you are going to start cleaning up the plant a little at a time, and start with Machine A.

Since nothing but example will serve at this stage, the boss dons a pair of overalls, picks up a couple of helpers and starts to give Machine A "the works" — face lifting, shampoo, teeth cleaning, manicure. Every loose or defective part is adjusted or replaced, every rattle and squeak removed. Then she gets a coat of paint to make the job stand out as a monument to the new order.

If the boss is the best maintenance man in the bunch, which he should be anyway, this one job will set the style. Good work, properly displayed, is catching. It won't take much pushing to get another machine cleaned up and put into shape. This time the boss won't have to do the work, but the good example he set will live on, for no mechanic likes to be shown up as a piker who can't do as well as the other fellow if he really sets his mind to it.

In a period ranging from a few months to a year, depending on the previous state of the plant and men, the plant will be in top-notch shape as far as maintenance can make it so. Then, when things are right, and all are enjoying the fruits of their labor, comes the resolution for a better life:

"Starting from now, we manage maintenance in this plant. From now on these machines won't tell us when they need fixing. We'll tell them. Here's a schedule of machines. Here are the dates on which they are to be cleaned up, inspected and maintained. Here are the men who are to do the job and here is the followup system to make certain the job is done according to schedule. And here is the storeroom with the spare parts ready for instant use."

The foregoing, in brief, is the philosophy of all good maintenance men, with a few modifications to fit a special situation.—*P W S*

Simplicity, Compactness, Ease of

▶ A SIMPLE COMPACT LAYOUT reduced first cost and stepped up ease of operation at Dunn Sulphite Paper Co's new power plant on the St Clair River, at Port Huron, Mich. Built to replace an outmoded power setup, this "small central station" efficiently supplies both steam and power for the manufacture of quality specialty papers from imported and domestic pulp.

Principal steam consumers are the drying sections of the two paper machines, and the beaters; pressure required varies in the neighborhood of 15-50 lb, depending on the paper being made and the speed of the machines. Since no pulp is made at the mill, there is no need for large quantities of high-pressure steam (150 lb) for digesters. Jordans, beaters, and paper machines represent the biggest electrical loads.

In the old power plant, three boilers supplied steam at 165 lb, part going directly to the mill, through reducing valves, and part going to a Corliss engine, the exhaust from which also went to the mill. Power needs over and above what the engine could supply were purchased.

When the time came to replace this plant, it was clear that higher boiler pressure would permit generation of nearly all electrical load as a by-product of process-steam requirements, materially improving the over-all economy. Accordingly, the engineers decided to use 620-lb, 725-F boilers supplying extraction-condensing turbines.

To keep first cost to a minimum and the layout, and consequently the operation, as simple as possible, the plant was designed on the unit principle. The first half, now complete, comprises a single 40,000-lb-per-hr steam generator supplying a 2000-kw turbine-generator. The plan and cross-section, Fig. 1, and the photo, Fig. 2, show how operating convenience and accessibility result from eliminating the division wall between boiler and turbine rooms, from placing control ends of boiler and turbine opposite across a single operating aisle, and from keeping the fans down on the operating level. Since plans call for future expansion of the plant by a similar boiler-turbine combination, the coal-handling and storage equipment stands at what will be the center of the completed plant.

Coal comes to the plant in self-unloading lake steamers. Using their long unloading booms, as shown in Fig. 3, the steamers pile the coal in the yard storage. A Caterpillar crane, previously in service, takes care of shifting the pile to the foot of an inclined continuous bucket elevator which lifts it to a 75-ton cylindrical steel bunker. A chute from the bunker discharges into an apron-feed coal scale.

The single bowl-mill pulverizer supplies two 7-in. combination oil and coal burners. Oil-handling equipment, including underground storage tanks, heaters and pumps, can handle full load, giving an alternate fuel to take care of emergencies. At present, operators use oil for light loads on weekends.

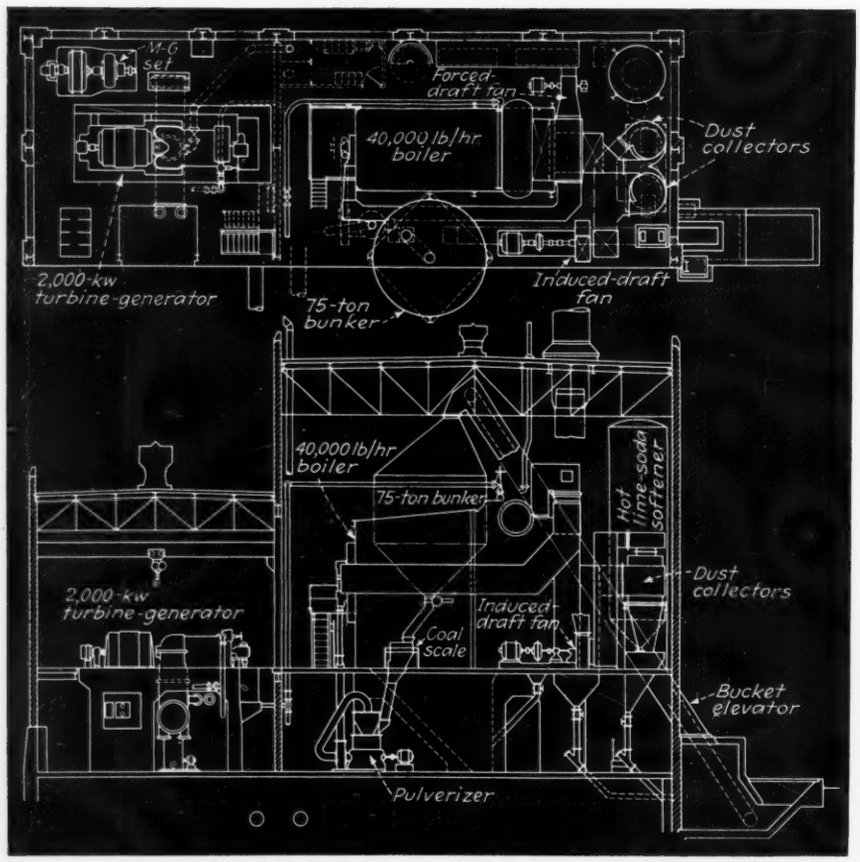


Fig. 1—Plan and cross-section show simplicity of layout, accessibility of equipment

Two-drum Boilers

The 2-drum, fully-water-cooled, integral-furnace boiler has a 4-hr maximum capacity of 48,000 lb per hr and is good for 40,000 lb per hr continuous. A glance at the plant cross-section shows the unusually large ash hopper, which materially reduces frequency of ash handling and so simplifies operation. Hoppers under the air heater and dust collector discharge into the common ash-disposal system.

A single, constant-speed, motor-driven fan handles forced draft. The single induced-draft fan, motor-driven through a hydraulic coupling for speed control, also on the operating floor, pulls boiler gases from the tubular air heater and discharges into a compound-cyclone dust collector. Air-operated combustion controls coordinate draft and fuel feed.

The feedwater system (see flow diagram, Fig. 4) is exceedingly simple. Condensate, returns from the mill, drips and drains, all go into a settling and deaerating section of the hot-lime-soda softener. Filtered water, from the general plant supply, goes into an auto-

Operation Mark Dunn Sulphite Plant

matic adjustable spray-heater section of the softener, where steam from the low-pressure header raises temperature of the makeup. Heated and deaerated feedwater is then pumped directly into the boilers, under control of feedwater regulators. Continuous blowdown keeps concentration at the desired point; the hot-process softener is arranged to utilize the heat available in the blowdown (not shown in diagram).

The flow diagram shows how existing 165-lb boilers fit into the new hookup. A reducing and desuperheating station connects the 620-lb header with a line running to the old 165-lb boilers. In normal operation, small quantities of steam flow through this connection for process uses in the mill. In an emergency, 165-lb steam from the old boilers can flow into the new turbine and steam driven auxiliaries, all of which can be operated at 165-lb. Under these conditions, a hand valve bypasses the impulse wheel of the main turbine.

Turbine Unit

The turbine, taking steam at 600 lb, 725 F is designed for automatic extraction at pressures varying from 5 to 50 lb g; the control for this feature permits either local or remote adjustment of extraction pressure. Five individually spring-loaded poppet valves, actuated by cams, control steam admission to the first stage. A double-seated balanced-piston valve regulates steam flow to the low-pressure blading beyond the extraction point. Both sets of valves connect through linkages and oil-relay cylinders to the speed governor and the extraction-pressure regulator, so that both respond to changes in electrical load, or process-steam load. Turning a handwheel at the pressure regulator changes the extraction-pressure setting, and the equipment is arranged so that the pressure setting can also be changed from a point in the mill.

The turbine drives a 2000-kw, 0.80-pf, 3600-rpm, 60-cycle, 3-phase generator, operating at 4800 volts to permit an emergency tie-in with the Detroit Edison system. A shaft exciter, rated 15 kw at 125 volts, supplies field current.

A 2080-sq-ft, horizontal single-pass surface condenser, with divided water box, handles steam sent through low-

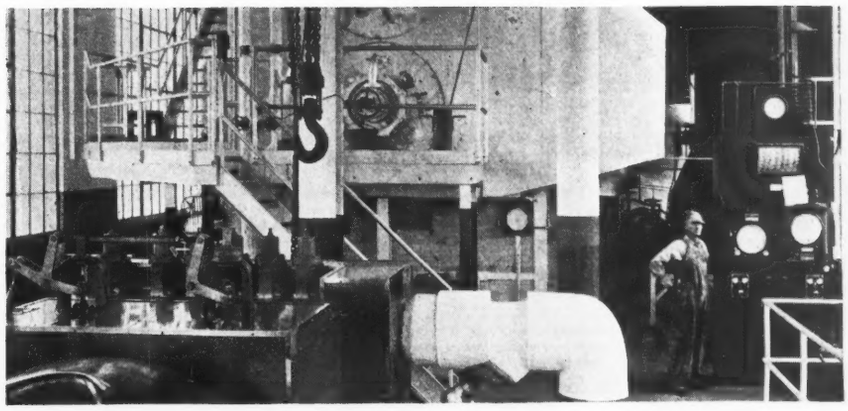


Fig. 2—Operator in aisle between boiler and turbine is convenient to controls of both

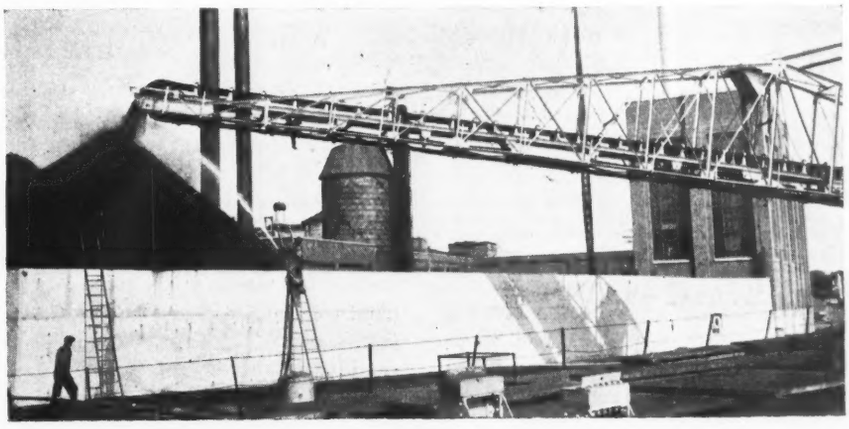


Fig. 3—Coal discharging from boom of self-unloading lake steamer. New power-plant building at rear

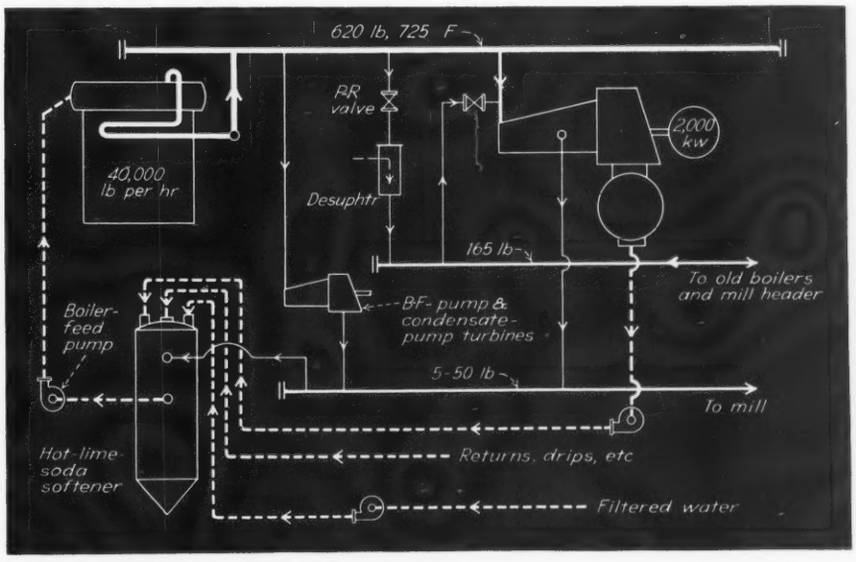


Fig. 4—Feedheating arrangement and tie between new plant and old boilers

PRINCIPAL EQUIPMENT—DUNN SULPHITE PAPER CO.

Port Huron, Mich.—Burns and Roe, Inc, Consulting Engineers

Steam-Generating Equipment:
Boiler, 2-drum, integral-furnace.....Combustion Engineering Co, Inc
Heating surface: 3850 sq ft. Capacity: 40,000 lb/hr at 620 lb, 725 F, max 24-hr rating; 48,000 lb/hr, max 4-hr rating. Guaranteed combined efficiency: 83.8% at 40,000 lb/hr. Upper rear drum fitted with bubble-type steam washers
Furnace, hopper-bottom.....Combustion Engineering Co, Inc
Water walls: 1622 sq ft, front and sides, bottom screen
Superheater, Elesco ball-joint, interbank.....Combustion Engineering Co, Inc
Air heater, tubular, 3775 sq ft.....Combustion Engineering Co. Inc
Soot blowers.....Vulcan Soot Blower Co
Water column, bi-color.....Diamond Power Specialty Corp
Safety valves.....Consolidated-Ashcroft-Hancock Div

Combustion Equipment:
Pulverizer, Raymond bowl mill, motor driven..Combustion Engineering Co, Inc
With integral exhauster. Capacity: 4910 lb per hr, nominal
Burners, 2, combination coal and oil.....Combustion Engineering Co, Inc
Burners and mill give a load range of 6:1, or 48,000 to 8000 lb/hr evap
Combustion control, full automatic, air-actuated.....Bailey Meter Co

Fuel-Handling Equipment:
Weigh scales, apron-feed, 100-lb hopper.....Richardson Scale Co
Coal bunker, 75-ton, cylindrical.....Beaumont-Birch Co
Oil storage tank, 12,000 gal.....Pittsburgh Des Moines Steel Co
Bucket elevator, inclined, continuous.....Beaumont-Birch Co
2-strand, 9-in. pitch, stock roller chain, overlapping 9x16-in. buckets, on 18-in. centers. Driven by 7.5-hp, 440-v, 3-phase, 60-cycle motor

Ash-Handling Equipment:
Flushing system .....Beaumont-Birch Co
Ash flushed from double-boiler hopper and single hoppers of air preheater and dust collector, by means of dust quenchers and necessary 8-in. CI piping, fittings, and machined rotary valves. Flyash from boiler last pass flows by gravity to the boiler ash hopper

Draft Equipment:
Forced-draft fan .....American Blower Corp
Capacity: 14,400 cfm at 9.63-in. H_2O static pressure. Motor-driven, through flexible coupling
Induced-draft fan .....American Blower Corp
Capacity: 25,900 cfm at 7.84 in. H_2O static pressure. Motor-driven, through hydraulic coupling
Dust collector .....Buell Engineering Corp
Two Van Tongeren-system cyclones, 2 volute gas dischargers, and common hopper. Efficiency: 99% of all flyash particles 43 microns and larger; 81% of all particles 10 microns and larger

Boiler-Feed System:
Boiler-feed pumps, 2, 2½-in., 6-stage diffuser type.....Dean-Hill Pump Co
One driven by Elliott, 125-hp, 3550-rpm steam turbine (600 lb, 725 F at throttle). One driven by 100-hp, 440-v, 3-phase, 60-cycle, 3450-rpm s-c motor
Feedwater regulators, Copes .....Northern Equipment Co

Feedwater Treatment:
Hot-lime-soda softener, 2400 gal per hr.....The Permutit Co
Includes 5000-gal-per-hr settling tank, 50,000-lb-per-hr deaerator, automatic adjustable spray heater for makeup, filter unit, chemical tank with motor-driven agitator, motor-driven chemical pump, phosphate tank and pump, and backwash pump

Generating Equipment:
Turbine, 2000-kw, condensing, automatic extraction.....Allis-Chalmers Mfg Co
Impulse-reaction type, 3600-rpm, 600 lb and 725 F at throttle, automatic control of extraction at from 5 to 50 lb
Generator, 2500-kva, air-cooled.....Allis-Chalmers Mfg Co
4800-v, 60-cycle, 3-phase, .8 pf, with 125-v, 15-kw shaft exciter
Generator air cooler .....Allis-Chalmers Mfg Co
Air circulated: 7650 cfm. Water required: not over 90 gpm
Condenser, horizontal, single-pass .....Allis-Chalmers Mfg Co
Divided water box, welded-steel shell, 2080 sq ft surface
Circulating pump, centrifugal .....Allis-Chalmers Mfg Co
Driven by 100-hp, 440-v, 3-phase, 60-cycle squirrel-cage motor
Condensate pumps, 2, centrifugal .....Allis-Chalmers Mfg Co
One driven by 7.5-hp, Allis-Chalmers impulse turbine, 1750 rpm, 600 lb, 5-50 lb backpressure. One driven by 7.5-hp, 440-v, 3-phase, 60-cycle, s-c motor
Evactor (air pump).....Croll-Reynolds Engineering Co
Atmospheric relief valve .....Atwood & Morrill Co

Miscellaneous Pumps:
Drip and drain pump, centrifugul.....Allis-Chalmers Mfg Co
Condensate-return vacuum pump.....Nash Engineering Co

Electrical Equipment:
Motor-generator set, synchronous, 300-kw .....General Electric Co
450-hp, 4800-volt synchronous motor (3-phase, 60-cycle) driving 1200-rpm, 250-volt compound-wound dc generator
Main switchboard, metal-clad .....Westinghouse Electric & Mfg Co
Hinged panels with semi-flush instruments. Oil circuit breakers: 600-amp, 15-kv, manual closing, electrical tripping. Five panels: main feeder to paper mill (4800 volts), service transformers, motor-generator set, turbine-generator main control, turbine-generator field and voltage regulator
Outdoor substation, service transformers.....Allis-Chalmers Mfg Co
3 150-kva. 4800/480-volt, single-phase, 60-cycle transformers

Piping, Valves:
Circulating water piping, electric welded ..... {Taylor Forge & Pipe Works / Murray W Sales & Co}
Steam and water piping .....Pittsburgh Piping & Equipment Co
Insulation on piping and softener tank.....Johns-Manville Co
Valves ..... {Chapman Valve Mfg Co / Edward Valve Mfg Co}
Reducing and desuperheating station .....Swartwout Co

Construction:
Stack, breeching, flues .....Connery Construction Co
Insulation, Eagle-Picher and Unibestos .....C H Gotshall Co
Structural steel .....Flint Structural Steel Co
Roof deck .....Federal American Cement Tile Co
3½-in. precast concrete channel slabs on boiler house, 2¾-in. precast concrete channel slabs on turbine roof
Roof drains .....The Barrett Co
Roofing .....The Barrett Co
Ventilators, 2, 36-in. protected-metal fans with dampers .....H H Robertson Co
Sash and doors .....Truscon Steel Co

pressure blading when electrical load is high in relation to process load. River water, pumped through the condensers, goes on to a storage tank from which, after treatment, it goes to the mill. This arrangement saves some of the heat rejected in the condenser, putting it to useful work in the mill. Duplicate condensate pumps, one motor- and the other turbine-driven, insure reliability.

A 300-kw synchronous-motor-generator set supplies dc for paper-machine drives. The main switchboard (metal clad, with hinged panels and semi-flush instruments) comprises 5 panels. A single transformer bank steps voltage down from 4800 to 480 volts, at which most motors operate. Low-tension equipment includes new "across-the-line" starters for auxiliary motors.

Since the power-plant building is an isolated structure, steam and power lines must run across the yard to the mill buildings. The photo, Fig. 5, shows the effective, low-cost method devised to carry pipe and cable. A steel frame at one corner of the power plant forms one anchorage, carrying spring hangers for the pipes. Single steel struts, with a cross arm, support pipe and cable between the buildings, the cable being strung in the usual overhead-line fashion, and the pipe being supported by interrupted-catenary slings.

Burns & Roe, Inc, were consulting engineers for the power plant. Theodore W Dunn is president of Dunn Sulphite Paper Co, and George C Dunn is secretary-treasurer.

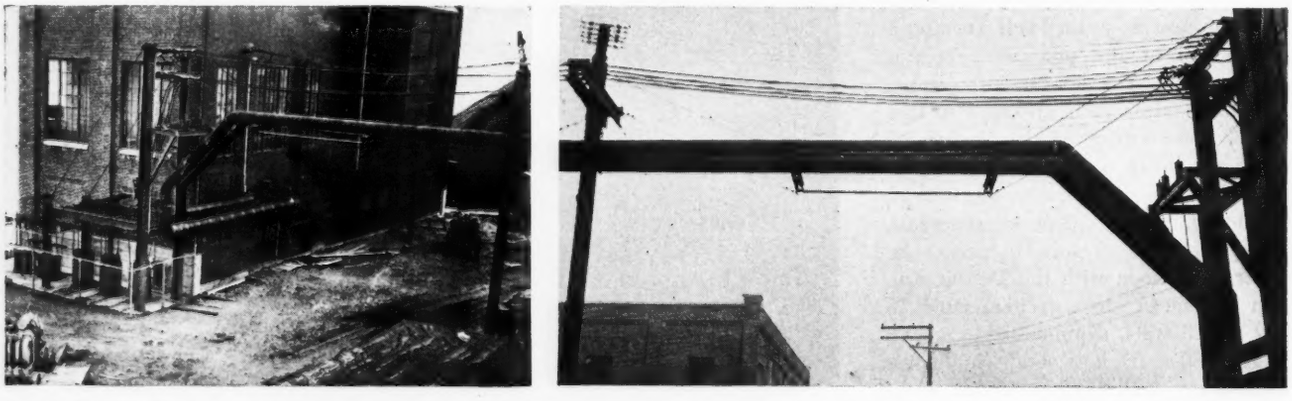
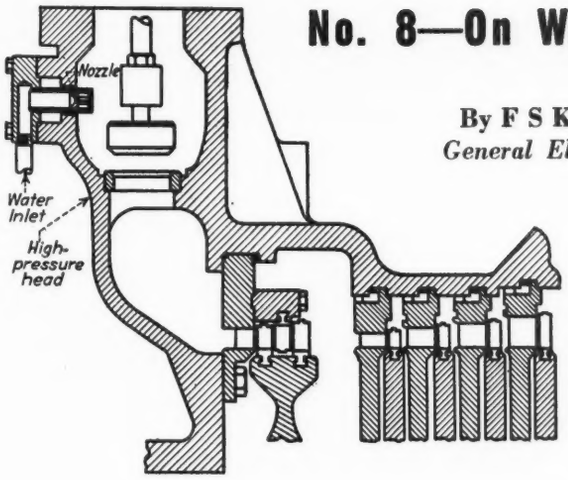


Fig. 5—Pipe and cable cross plant yard; one view (left) shows anchor at power-plant end, the other shows method of slinging pipe

LETTERS FROM A TURBINE SPECIALIST

No. 8—On Washing Out Turbines

By F S KOHL and H M KING
General Electric Co, Lynn, Mass.



Dear Mr Specialist:

Your letter covering our proposed 5000-kw superposed turbine has just landed on my desk. In one of the paragraphs covering accessories you state that you will provide a "washing-out" nozzle if it will be of any use to us. Washing out turbines is a new subject to me and I would appreciate some education on it. Could you drop me a note of explanation?

Very truly yours,
Engineer

Dear Mr Engineer:

The "washing-out" of a turbine is merely the practice of operating it with wet steam in order to wash water-soluble deposits out of its steam path. These deposits form under certain conditions and their removal is important. Were they left to accumulate, efficiency and capacity might materially decrease.

Among the installations using moderate and high pressures and temperatures, there are some cases where soluble salts from the feedwater are carried over from the boiler into the turbine. These salts are deposited by impact on dry surfaces over a certain temperature range. Since they are soluble they are not deposited on wet surfaces as these are continuously "washed." Dry surfaces exist in most topping turbines all the way down to the exhaust, while in condensing units they exist only down to the "dewpoint." Deposits in the strainer and the nozzles and buckets are the most serious, but those in the throttle valve, steam chest, and on valve stems are also troublesome and dangerous.

These deposits increase the surface friction and change the shape of the nozzles and buckets, lowering the efficiency of each affected stage. Nozzle areas are reduced, making it impossible to pass the maximum designed steam flow, thereby reducing capacity of the unit and upsetting energy distribution of the various stages, causing a still further drop in efficiency. Deposits on the valve stems cause stickiness, hinder their movement, and may prevent them from closing in the event of loss of load.

The need for washing varies in different units; experience will tell when the deposits become appreciable. Deposits usually cause a reduction in the maximum capacity of the unit and an increase in certain of the stage shell pressures for any given load or steam flow.

Preferably, washing should be done at low speed and without load. Care should be taken under these circumstances to see that pipe velocities are maintained high enough. This is done by dropping the pressure so as to bring the water to the turbine in a fine mist and not in slugs. Turbines have been washed safely at full speed and partial load, but the risks are such that this procedure is not generally recommended.

How To Inject Water

Turbines in which soluble deposits occur are normally operated on steam with reasonably high superheat. Wet washing-steam can usually be obtained conveniently by injecting water into the steam supply in an amount sufficient to desuperheat it and to create a moisture content of from 2 to 5%. The water is ordinarily taken from a high-pressure feed line and is injected into the steam flow through a nozzle in either the inlet piping or in the steam chest.

Flow of the water should be controlled so that steam temperature does not drop at a rate faster than 75 to 100 deg an hour. Decreasing the temperature slowly minimizes the possibility of having unequal contractions of turbine parts and reduces possibility of vibration during the process.

Washing should last for about an hour, or in cases where reasonably heavy deposits are encountered, until the water drained from the casing is of the same analysis or electrical conductivity as the feedwater. In putting the unit back under normal operation, follow the reverse procedure, being careful to make the transition slowly. With proper operating care no difficulty should be encountered.

Under certain circumstances, some turbines connected to one boiler have been washed without introducing water, but by running or, more preferably, starting them at loads low enough to obtain nearly-saturated steam from the boiler.

Effect of Loading

Turbines operated at constant load are more likely to accumulate deposits than turbines subjected to variable load or frequent shutdowns. Soluble deposits will often be washed out when a unit is restarted after a 2- or 3-day shutdown.

After reading this you might say, and rightfully so, "all well and good for soluble deposits, now how about the insoluble ones." These do occur in some installations and have to be removed by mechanical means when the unit is opened for inspection. Insoluble deposits are not as common as soluble ones. In modern stations, particularly those of moderate and high pressures and temperatures, carryovers that cause deposits of this type are controlled by proper feedwater treatment and boiler operation.

Should you decide, after studying your feedwater conditions, that carryover is expected, it would be advisable to call for a washing-out nozzle in your new unit. The best practice, however, is to remedy the carryover at the source to minimize the necessity of washing.

Sincerely yours,
Turbine Specialist

Gas Engines Take on Another Job

Water companies find natural-gas units make economical and flexible pumping plant drive. G H Dieter, Southern California Gas Co, describes three typical plants showing application of safety devices, methods of engine cooling, arrangements for automatic operation, performance on pumping loads

▶ DURING THE PAST 10 YEARS, mutual water companies and farmers in Southern California, requiring a flexible, dependable, and economical form of power, installed approximately 100,000 hp in natural-gas engines, mostly driving deepwell and centrifugal booster pumps on irrigation systems. However, most domestic water companies and water utilities hesitated to install gas engines because they had to be manually started and stopped, while electric plants were fully automatic.

Improved methods of engine application and control now make it possible to realize the advantages of gas-engine economy and variable-speed flexibility and an increasing number of these units drive pumping plants owned by water utilities. The three plants described here illustrate application of safety devices, methods of engine cooling, arrangements for automatic operation, and performance of gas engines on pumping loads of this type.

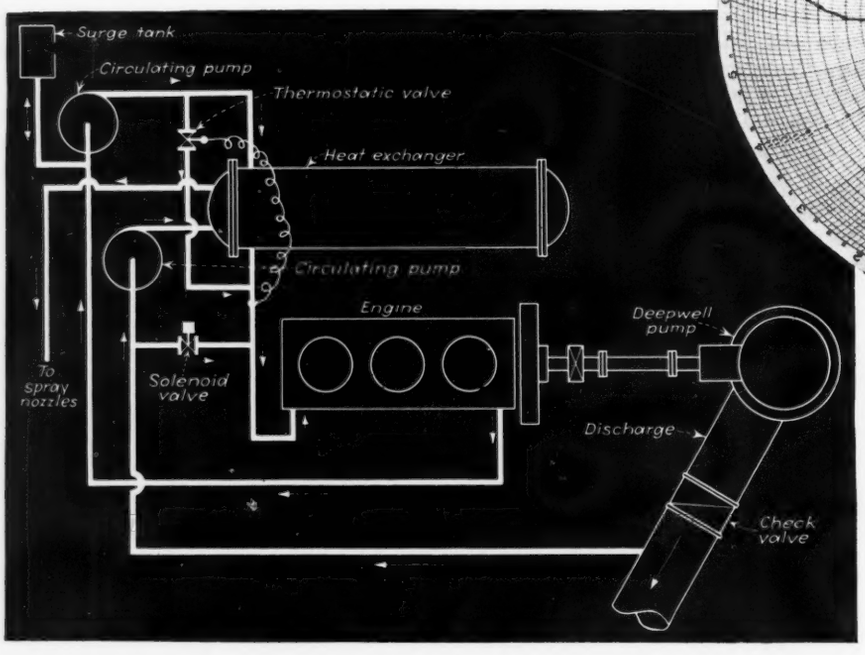
Southern California Water Co

The Southern California Water Co (J B Whitworth, president; C P Harnish, executive vice-president and chief engineer; and L J Alexander, designing engineer) supplies considerable territory in Southern California. Its South Los Angeles distribution system consists of nine deepwell pumping plants, three booster plants, two settling basins, one reservoir, and one 250,000-gal overhead storage tank to maintain 60-lb pressure on the system.

The three boosters and eight of the nine deepwell turbine pumps are direct connected to motors while the remaining pumping plant consists of a Layne & Bowler deepwell turbine pump driven by a 90-hp, 514-rpm, Worthington natural-gas engine, with a Farrel-Birmingham, right-angle speed-increaser (2.49-1) gear.

For emergency protection, safety shutdown devices stop the engine by shorting the magneto, if it overspeeds, if circulating-water pressure falls, or circulating-water temperature rises. If engine oil pressure drops below a predetermined limit, another shutdown device closes the fuel line ahead of the mixing box. This means that whenever the engine stops, for any reason, the gas supply line automatically closes.

As shown in Fig. 1, a double-circuit system cools the engine. One of two circulating pumps takes suction from the jackets and pumps through a heat exchanger back to the engine; a surge tank keeps the system filled with water and provides an escape for air. To secure the constant inlet-water temperature needed for best operation, a ther-



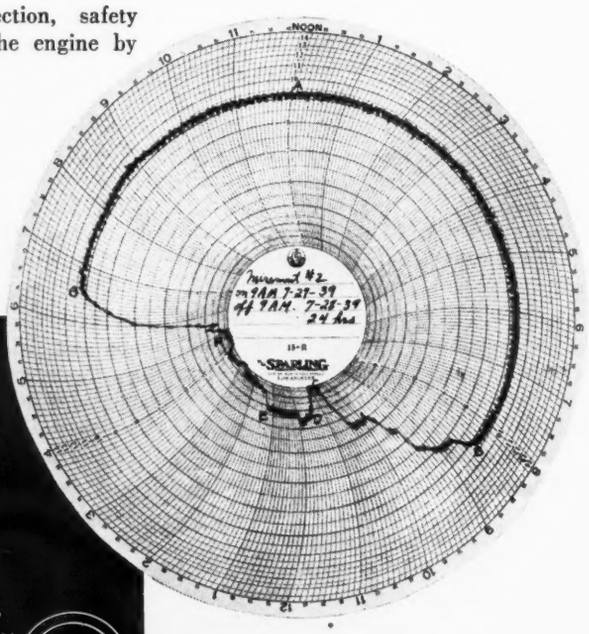


Fig. 1 (left)—Double-circuit cooling system for Southern California Co's engine. Fig. 2 (above)—Pumping-rate chart shows variable-speed flexibility of gas engine

mostatic valve regulates flow in a bypass around the heat exchanger.

In the raw-water circuit, a second circulating pump takes suction from the deepwell-pump discharge, between the check valve and the overhead tank, and pumps cool water through the exchanger tubes and then to the top of the overhead tank, through spray nozzles.

In many pumping plants, the heat exchanger forms a part of the deepwell discharge line, eliminating the raw-water circulating pump. Since all water pumped by the main unit passes through the tubes, all engine heat dissipates in the water system. This setup was not chosen for this plant because: (1) ground-water temperature was such that additional heat pickup would produce a final temperature higher than desirable, (2) it was important to be able to clean or repair the heat exchanger without shutting down the plant, which runs continuously, and (3) it was desired to use the spray nozzles to cool air and water directly beneath the roof of the overhead tank.

If electrical service to the two motor-driven circulating pumps fails for more than 10 seconds, pressure in the closed circuit will drop enough to cause the low-pressure safety device to shut down the engine. To keep the engine running, a bypass with a solenoid valve connects the raw-water-pump suction and soft-water-pump discharge. Failure of electric service opens the solenoid valve, allowing cool water, under pressure of the overhead tank, to flow through the engine to the surge tank and then the sewer. As soon as electric service is restored, the solenoid valve closes, the pump starts, and the plant operates as usual.

This engine plant operates 24 hours a day, pumping directly into the overhead storage tank. The operator visits the plant twice daily, at 8:30 AM and 3:30 PM. Water level in the overhead tank, working through a Mason-Neilan pressure-speed control attached to the governor linkage and to the discharge line from the tank to the system, regulates engine operating speed and quantity of water pumped.

The chart (Fig. 2) shows quantity of water pumped for a typical day, and illustrates the operation of the engine control. As long as the tank level stays below 27.5 ft, the engine runs at 500 rpm and the pump delivers approximately 925 gpm (*A* to *B* on chart). When the level reaches 27.5 ft, the control device gradually decreases engine speed, at a rate depending on system drawdown, until the level reaches 29 ft and speed falls to 370 rpm (*C* on chart). At 29 ft, the check valve between pump and tank closes, and the engine drops back to idling speed (250 rpm), just enough to maintain about 5-lb pressure against the closed check valve. The engine governor controls this idling speed; the control device regulates higher speeds.

The engine continues to idle until the tank level falls back to 28 ft, then the control device gradually increases engine speed as the water level continues to fall, until the engine again runs at 500 rpm, at which time the tank level has fallen to 26.5 ft (*F* to *G* on chart). If there is a sudden demand while the engine is idling, causing the level to drop to 28 ft, the control forces the engine to run faster to meet the demand and then refill the tank after the sudden drawdown has been taken care of (*D* to *E* on chart). This means that the overhead tank is always practically full during off-peak hours.

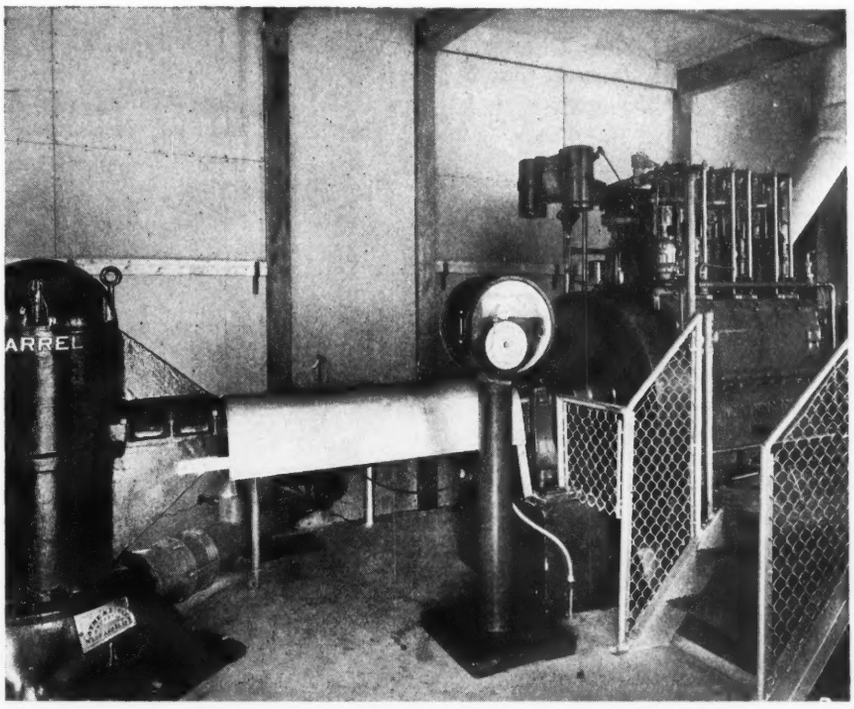


Fig. 3—90-hp gas engine in Southern California Water Co plant

Plant Control

One of the motor-driven plants operates continuously, while the others, operating on pressure switches, start automatically in sequence, when the single electric plant and the gas-engine unit cannot maintain water level above 22 ft. They stop in reverse order, the last one cutting out when the water level reaches the 24-ft mark.

Tests made on the gas-engine-driven pump show the effect of variable speed on pump efficiency. At 1050 rpm, the pump delivered 595 gpm against 238.66 ft total head, with an over-all efficiency of 73%. Efficiency was 75.5% at 1170 rpm, 827 gpm, and 246.85 ft total head,

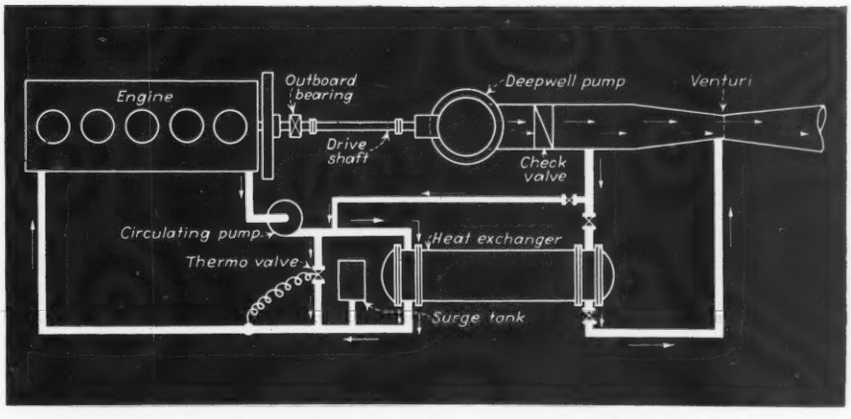


Fig. 4—Double-circuit cooling system for Conservative Water Co's engine

and 73.5% at 1304 rpm (maximum pump speed), 1026 gpm and 252.6 ft head. The well is in sandy soil and the modulated-speed operation will, no doubt, give greater useful life than would intermittent operation.

Cost of pumping on this system for March, April, May and June 1938, with all plants electrically driven and based on 50 million cu ft, was $0.0126 per 100 cu ft. On the same basis, and during the same months of 1939, with the gas-engine pumping 35% of all water, the cost was $0.0102 per 100 cu ft, a saving of 19%.

Conservative Water Co

The Conservative Water Co, under direction of O B Frank, general manager, and Walt Harrison, engineer in charge of pumping plants, serves approximately 7500 meters in the city of Watts and the surrounding county territory. The distribution system consists of 75 miles of mains, three deep-well pumping plants and a 35,000-gal. storage tank, elevated enough to maintain only 35 lb on the system.

Prior to June 1939, all three plants were motor driven, two direct-connected (125 hp and 75 hp) and one (50 hp) belted. Fig. 5 shows typical system pressures with this setup. The operator attempted to juggle combined operations to maintain 60-lb system pressure. During night hours, when demand was less than the smallest plant's capacity, pressure was reduced to 30 lb, and the tank was put on the system to maintain this pressure. As can be seen from the chart, one of the plants was on automatic control to fill the tank when necessary.

In June 1939, Mr Frank replaced the 125-hp motor with a 150-hp, 514-rpm, Worthington gas engine, driving a Layne & Bowler deepwell turbine pump through a Farrel-Birmingham right-angle speed-increaser gear (3-1). Careful muffling, which renders the exhaust inaudible 25 ft from the pumphouse, makes the plant satisfactory for its residential location. The engine is fitted with the safety shutdowns previously described.

Fig. 4 shows the double-circuit cooling system. The circulating pump, belt-driven from the engine shaft, pumps water from the engine jackets through a heat exchanger and back to the jackets. A thermostatically controlled bypass holds inlet temperature constant, and a surge tank is provided.

Since this plant also operates continuously, the heat exchanger is installed so that it can be worked on without interfering with engine operation. After considering several plans, the engineers put a 6-in. venturi in the 12-in. discharge line from the deepwell pump. The inlet to the heat exchanger takes off the main discharge just beyond the check valve, and the outlet enters the line again at the venturi throat. With engine running at full speed, approximately 165 gpm flows in the heat-exchanger circuit, with less than 0.5 lb pressure drop in the venturi, which, under maximum conditions, equals approximately 0.5 water hp.

Engine Speed Control

Since completion of the gas-engine plant, the overhead storage tank has not been used. The engine pumps directly into the mains and demand for water governs engine speed through a C M Bailey, pilot-operated, pressure-speed control device. The engine governor sets maximum speed, and the control device regulates all speeds below maximum. Figs. 6 and 7 show system pressure and water flow for a typical day after installation of the engine. During the day the operator starts and stops the two motor-driven pumps to pump as much as possible with the engine unit. At times, all three pumps are needed to keep 60 lb on the system.

A careful study of Figs. 6 and 7 reveals how engine speed increases when the 75-hp motors cut out and the 50-hp cut in, and vice versa. It also

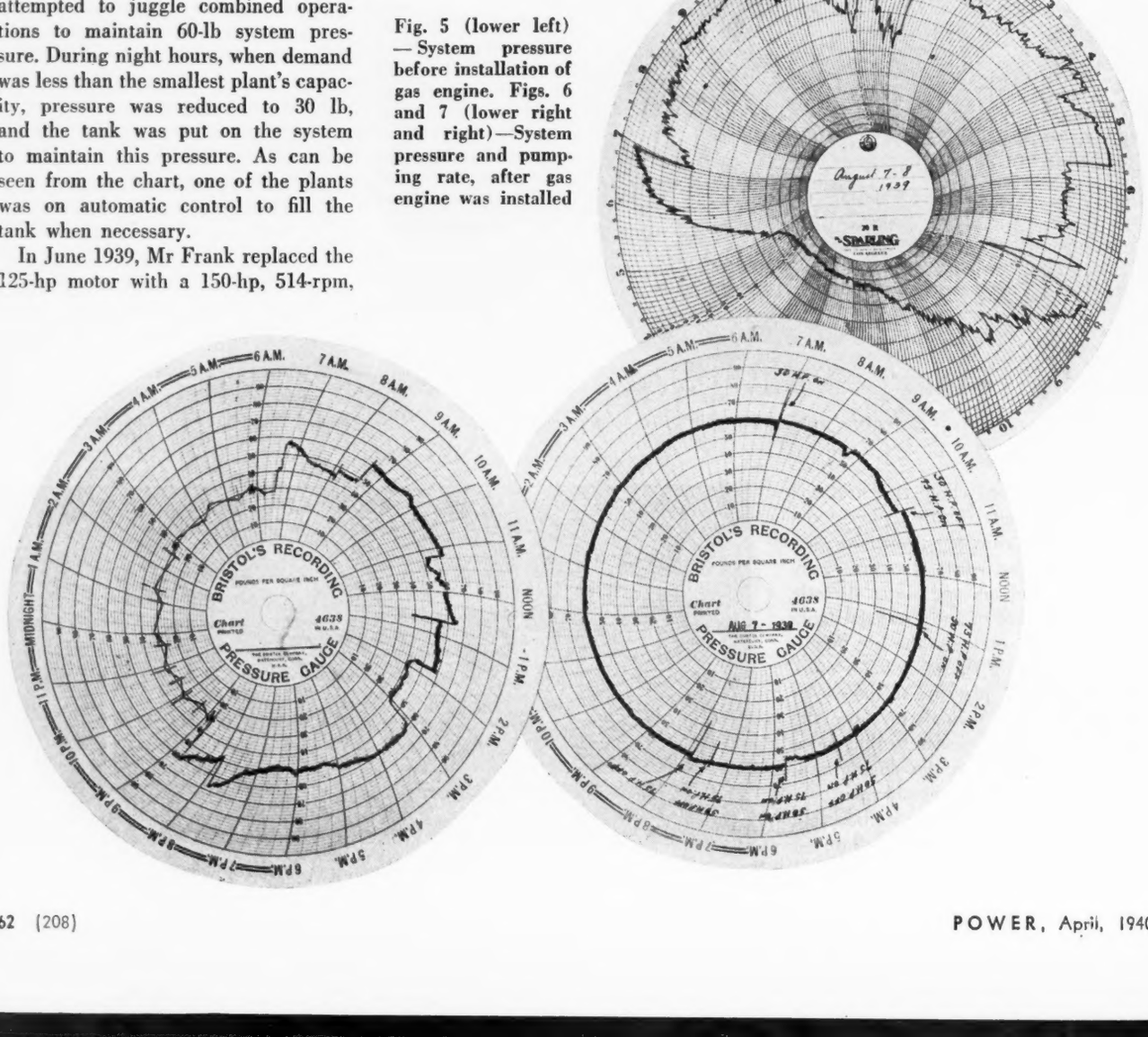


Fig. 5 (lower left) — System pressure before installation of gas engine. Figs. 6 and 7 (lower right and right) — System pressure and pumping rate, after gas engine was installed

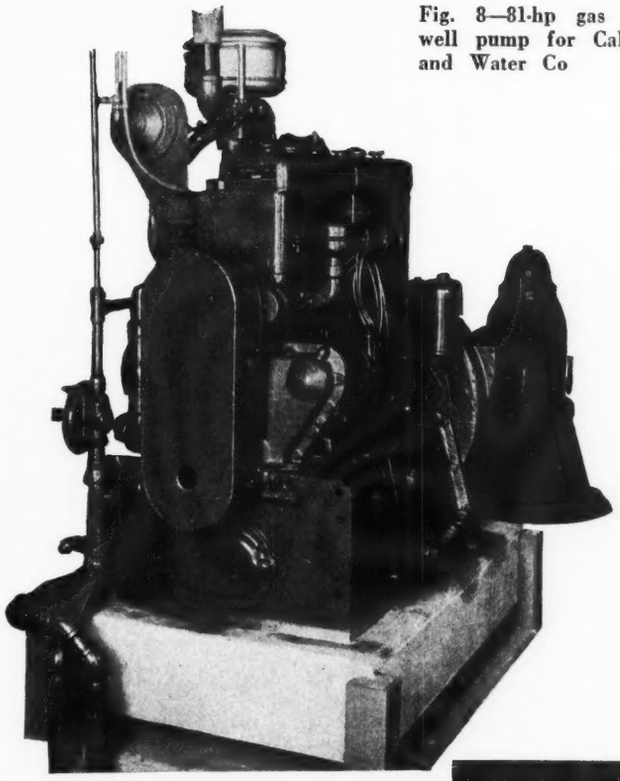


Fig. 8—81-hp gas engine driving deepwell pump for California-Michigan Land and Water Co

shows how engine speed decreases during the night to deliver only enough water to maintain 60-lb pressure. This plant pumps from 450 to 1750 gpm during a 24-hr period.

Since July 10, 1939, Mr. Frank estimates that the monthly saving in operating cost over corresponding months of last year runs slightly over $300 per month. He anticipates that steady system pressure will cut pipe maintenance.

Both this plant and the Southern California Water Co plant are semiautomatic, that is, they run automatically and stop when safety devices go into action, but once stopped, they must be started manually. The next plant illustrates full automatic control.

California-Michigan Land and Water Co

The California-Michigan Land and Water Co (R C Goodspeed, president; R O Deeter, field superintendent) is a utility serving part of the East Pasadena area. The system consists of four deepwell pumping plants, one booster, and four reservoirs. Motors drive the booster and three of the deepwell units. The other deepwell plant consists of a 81-hp, 1090 rpm, Waukesha gas engine driving a Pacific pump through a Peerless right-angle speed-increaser gear (3-2). The usual safety devices protect this engine, and electric starting depends on a Bendix gear powered by a panel of storage batteries, charged when the engine runs. The installers, Frazier Wright Co of Los Angeles, took special pains with exhaust muffling to prevent annoying noise.

The extremely simple cooling system is shown in Fig. 10. A circulator on the engine pulls water from the jackets and through a run of about 80 ft of pipe in the pump discharge line, before discharging to the inlet side of the jackets.

Fig. 9 shows the location of three reservoirs with respect to each other and the engine-equipped pumping plant. A common discharge line connects the pump and the three reservoirs, entering 2 and 3 at the top and 1 at the bottom. Check valves are at the pump outlet and at reservoir 1, since it is highest.

Each reservoir has a Fisher pilot-operated float control valve. The fully automatic controls stop the engine when all reservoirs are full and start it whenever water level in any of the three drops to a predetermined point.

To follow operation, assume all reservoirs full, float-control valves at *2* and *3* closed, both check valves closed, and the engine stopped. Pressure in the discharge line, between the various valves, is the same as the head pressure at *1*, due to the bypass around the check and float-control valves at *1*. If the level in *2* drops to a point where the float opens the control valve at *2*, the resulting sudden drop in line pressure operates a Penn magnetic switch in the pumphouse, starting the engine. The head pumping to *2*, is approximately 25 ft; engine speed is regulated by the head so the pump delivers about 600 gpm to this reservoir. As soon as the reservoir is full the float valve closes.

The engine continues to pump and builds up sufficient pressure to open the check valve at *1*. If the float-control valve is open, indicating the reservoir is not full, the engine, now running at higher speed, will deliver 600 gpm into this reservoir against the 97-ft head. When the reservoir is full, the float valve closes and the sudden pressure increase in its closing stops the engine through the magnetic switch. The check valve also closes. If the float valve had been closed when the pump first opened the check valve, the engine would have stopped without pumping into reservoir *1*. If reservoir *3* starts the pumping, the same procedure repeats, head being 67 ft and delivery 645 gpm.

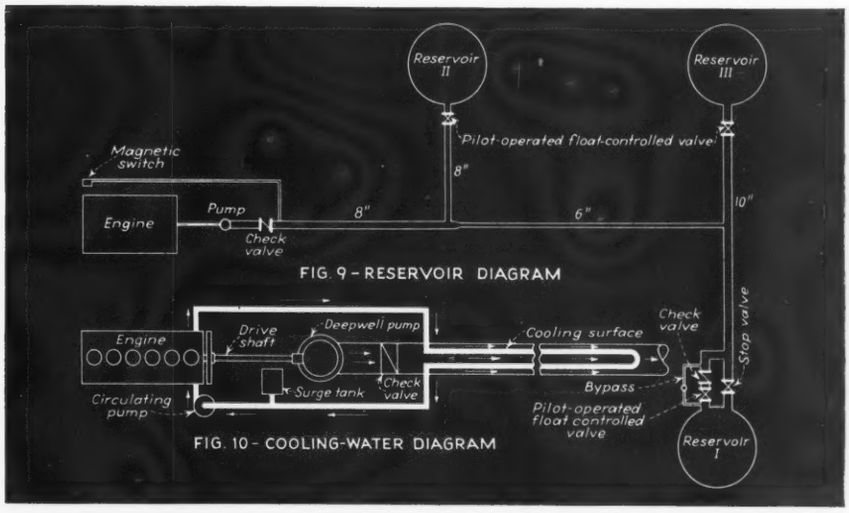


Fig. 9 (above)—Location of engine pumping plant, reservoirs, and control valves California-Michigan Land and Water Co. Fig. 10 (below)—Simple engine cooling system utilizes heat-exchanger surface in pump discharge line

Lubrication by Force Feed

Although first used over 40 years ago, force-feed lubricators are still the simplest and most widely used automatic-lubricating devices. In this article, Associate Professor James I Clower of Virginia Poly, one of POWER'S best-known contributors and author of the recent book, "Lubricants and Lubrication", explains how they work and how to use them on engines, compressors and other machines

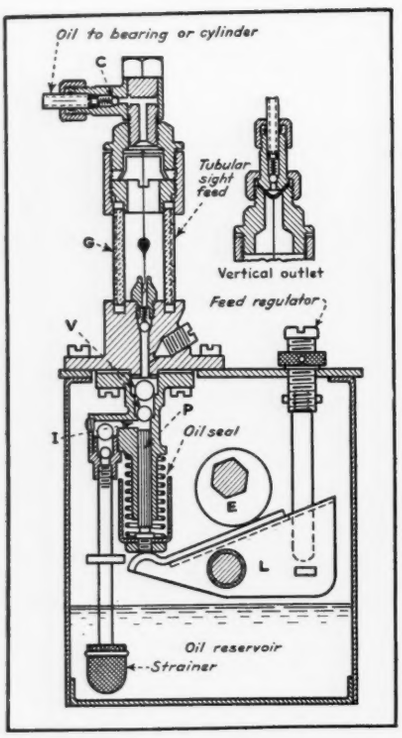


Fig. 1—General-purpose force-feed lubricator for pressures up to 1500 lb

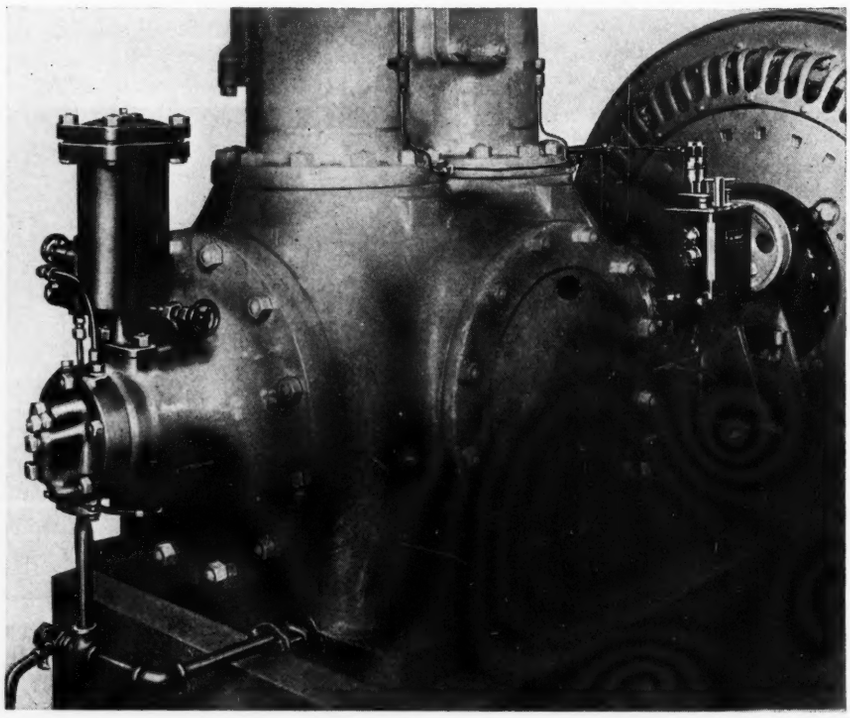


Fig. 2—Two-feed force lubricator, driven by a moving part of the machine, supplies oil to a 2-cylinder refrigerating compressor

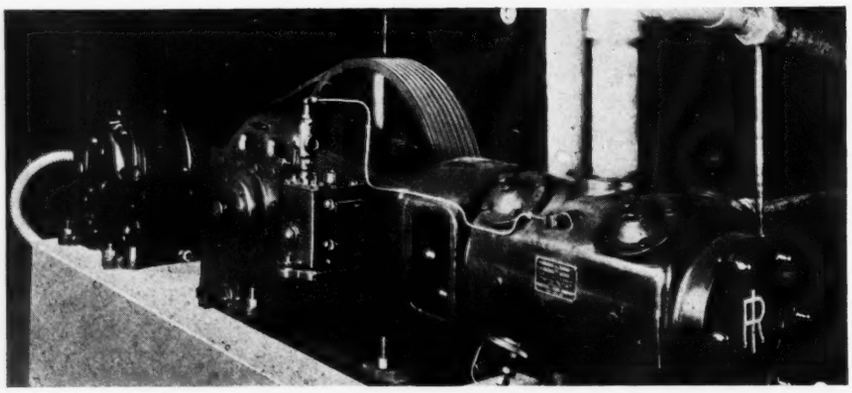


Fig. 3—Single-feed force lubricator on a single-stage, horizontal air compressor

► FORCE-FEED LUBRICATORS were the first mechanical devices used for automatically oiling bearings. Although introduced over 40 years ago, they are still the simplest and most widely used appliances for automatic lubrication. They are adaptable to virtually all machinery where it is desirable or necessary to deliver oil, under pressure, to the bearing surfaces, such as on steam cylinders and valves; cylinders of diesel, gas and oil engines, air and refrigerating compressors; mechanical stokers and many other machines.

In general, force-feed lubricators are

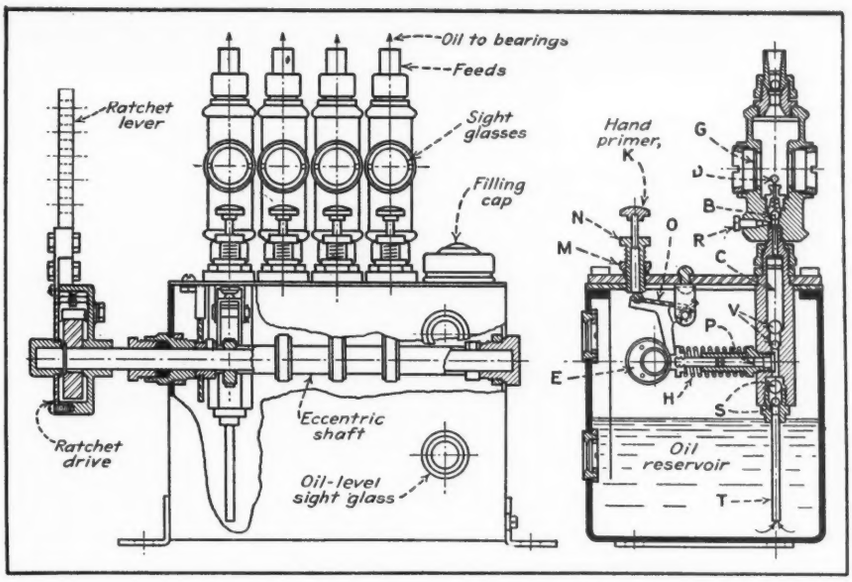


Fig. 4—Four-feed, eccentric force-feed lubricator

mounted rigidly on the machine frame and are driven by a moving part of the machines that they serve, as in Fig. 2. They may be mounted off the machine at some convenient nearby point and driven by an electric motor, or another machine. From the lubricators, individual oil-feed lines run to various bearings or other parts of the machine that require lubrication.

How They Work

As shown in Figs. 1 and 4, a force-feed lubricator is essentially a precisely constructed reciprocating pump. In Fig. 1 the eccentric *E* is rotated by a ratchet, pulley, or some other device, and makes contact with one end of regulating lever *L*. The other end of *L* contacts plunger *P* and moves it up and down in a straight line. Oil is thus forced through ball check valves *V*, sight-feed glass *G*, check valve *C*, and into the bearing feed line. All working parts are inside the reservoir and self-lubricated. There are no outside moving parts except the driving gear. Amount of oil supplied to the bearings depends on the plunger stroke, which may be adjusted by the feed regulator.

Made in sizes of from 5 to 28 pt, the lubricator, Fig. 1, can serve from one to 20 feeds. Each feed is provided with an individual pump unit, and each feed may be regulated independently of the others. Oil shows in the sight glass after it has passed the pump and is on its way to the machine cylinder or bearing. Sight feeds are filled with a mixture of water and glycerine, or, when used on ammonia compressors, with pure glycerine. A hand crank permits using the lubricator before starting the machine, filling the oil pipes when the lubricator is first installed, or momentarily increasing the oil flow while running.

A two-feed model of the lubricator, Fig. 1, is shown in Fig. 2, supplying oil to the cylinders of a vertical ammonia compressor.

Another lubricator, on which the eccentric shaft is rotated by an external ratchet drive, is shown in Fig. 4. Oil delivery occurs when the eccentric moves plunger *P* to the right. Helical spring *H* pushes the plunger to the left on the suction stroke, and oil flows through tube *T*, past suction valves *S* and into the pump cylinder. On the discharge stroke, the plunger forces the oil past discharge valves *V* and check valve *B* in base of sight glass *G*, which is filled with a water-glycerine mixture. An oil drop *D* forms on the nozzle and passes up through sight glass *G* and onto the bearing or cylinder.

Amount of oil delivered is controlled by limiting the stroke of plunger *P* by adjusting screw *N*, which acts on bell crank *O*. Each pump unit can be operated by pushing down hand primer *K*. Fig. 3 shows a single-feed model of this lubricator, supplying oil to the cylinder of a single-stage, horizontal air compressor.

Seven-Feed Lubricator

The seven-feed lubricator, Fig. 5, differs markedly in design details from those just described, but operates on the same general principle as a plunger pump. An independent pump unit is provided for each feed. The plungers are actuated by eccentric *E*, and lifting disk *D*. Plungers *P* are locked to disk *D* by adjustable nuts *A* and lock nuts *N*. The piston and shank portions of plunger *P* are eccentric with respect to each other. Lifting disk *D* is not only given a reciprocating up and down motion by eccentric *E*, but also a turning motion near the ends of the stroke. Rotary motion of disk *D* is also imparted to plungers *P* because of the eccentricity of the shank and piston. Rotation of the pistons opens and closes the cylinder suction and discharge ports. This lubricator is said, therefore, to be valveless.

Although the lubricators, Figs. 1, 4 and 5, are typical of modern general-purpose types, there are many others, some of which are especially designed for specific applications. They are made for either right or left-hand drive by ratchet, gear, pulley, or motor; in

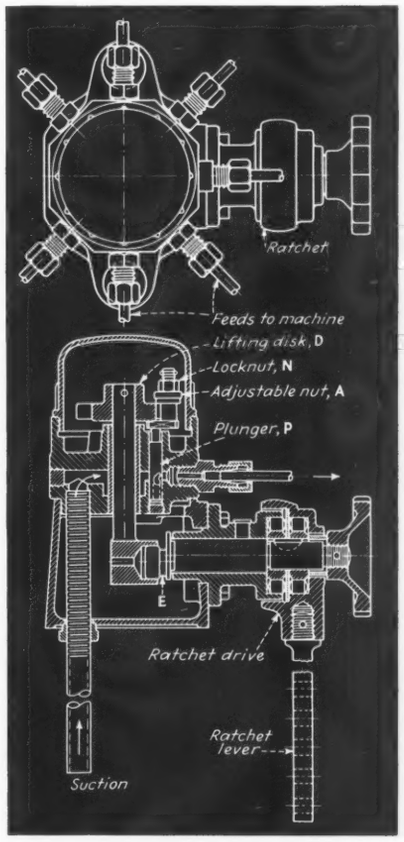


Fig. 5—Seven-feed valveless force-feed lubricator works on idea of plunger pump, with a pump unit for each feed

vertical or horizontal patterns; with one or more individual oil compartments for handling different grades of oil; with one to as many as 32 adjustable individual feeds; and with reservoirs having capacities from one pint to four gallons. Various finishes are obtainable—nickel plated, painted, black enamel, polished brass, etc. Lubricators provided with steam or electric heating elements meet outdoor service and other severe weather conditions.

Erratic Vibration—A Case for the

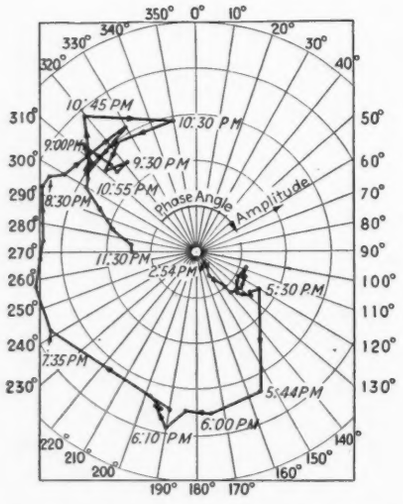


Fig. 1—This irregular diagram is typical of a wandering rub

On rare occasions rotating machines suddenly run rough, then vibration strangely disappears. Remedy recommended is to call a specialist with tools and experience, says R P Kroon, head of steam research for Westinghouse Electric & Mfg Co

►STEADY VIBRATIONS due to ordinary unbalance can be cured once and for all by proper balancing of the rotor. Within the last ten years the art of balancing has developed from a craft into a science. Methods and equipment have been established to reduce the number of trial runs to a minimum*.

But on rare occasions, vibrations may appear at random and for a short time without apparent reason. Such erratic vibrations are rare, but, because of their apparently unpredictable nature, are especially annoying to the operator. And when severe, it is important to get at the cause quickly to avoid outage of the unit and keep possible damage to a minimum.

Cases of this kind call for a technical and analytical approach based on accurate and highly specialized instruments. Ordinary observation is apt to conclude that the vibration is random and unpredictable. Modern instruments disclose a wealth of detail information to the experienced investigator and often lead him immediately to the cause of the trouble.

The first step is to catalog the types of vibration into classes against which any new case can be checked. The classes of vibration which are listed here are quite general for all rotating machinery but turbines have been chosen for the examples as they combine high speed and high temperature. Also, the presence of steam gives rise to some interesting special problems.

The first and most important class of erratic vibrations covers those *synchronous with the running speed of the machine*. In other words, it takes exactly one revolution of the rotor to complete one whole cycle of vibration.

Ordinary unbalance creates vibration of this type. Centrifugal force due to the unbalance repeats itself with every turn of the rotor and each point of the machine is forced to go back and forth or up and down exactly once every revolution.

How Vibration Happens

Spells of vibration resulting from unbalance can happen in two ways: (1) The unbalance is constant and always present but the "vibrating system" (rotor, stator, casing, foundation) becomes more or less sensitive to the unbalance, (2) the structural system stays the same but the unbalance varies.

The first of these is important only when the unit is operating in a critical-speed range where it is sensitive to relatively small changes in flexibility of the structure and where the damping properties are important.

Fortunately, the investigator has means to decide quickly, by making measurements at several points on the machine during the vibration spell, whether he has to deal with type (1) or type (2)**. In the first case, the cure can be either to obtain a very fine balance (which may not be possible for all operating conditions), or to change the critical speed by altering flexibility or mass of stationary or rotating parts. The second class includes a number of cases that are of special interest:

(a) History discloses occasional loose bodies inside hollow rotors. Where the wandering of the body is confined to a rather small lengthwise portion of the rotor, the machine will come up to speed about equally rough each time, but the plane of eccentricity of the rotor can vary at random. Where the loose body can wander along a major part of the rotor length, magnitude of the vibration can be anything. One characteristic of this case is that generally the vibration is not influenced by changes in load, temperature or pressure.

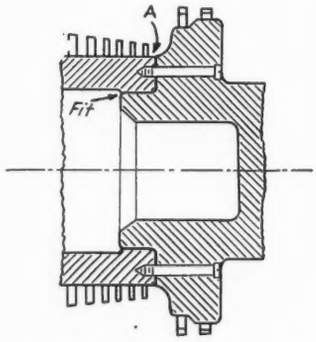


Fig. 2—Older hollow-rotor stub-shaft construction can start vibrating when sudden temperature changes are induced

(b) Relatively few years ago, when new alloys were introduced for rotors operating at high temperature, it was found, in some cases, that the rotors distorted when high temperature was applied (a sort of "bi-metallic" effect). This has now been overcome by more uniform heat treatment.

(c) Sometimes, due to lack of clearance under certain operating conditions, rubs occur between rotating and

* For modern balancing methods and equipment see: "Dynamic Balancing of Rotating Machinery in the Field," by E L Thearle, Trans. ASME, 1934. "Balancing Rotors by Means of Electrical Networks," by J G Baker, Journal of the Franklin Institute, August, 1936. "Methods of Rotor-Unbalance Determination," by J G Baker, ASME Journal of Applied Mechanics, March, 1939.

** For details see "Spiral Vibrations of Rotating Machinery," by R P Kroon and W A Williams. Proceedings of the Fifth International Congress for Applied Mechanics 1938, page 712. John Wiley & Sons, Inc, New York.

Specialist

stationary parts. If the rotor runs eccentric, it will be rubbed at its most eccentric point (provided the vibratory motion of the stator is negligible compared with that of the rotor). Due to the rubbing, this most eccentric portion of the rotor is then heated and distortion begins.

If the rotor could now be momentarily stopped, one would find a distortion in the same plane as the initial rub. However, according to the laws of dynamics this *static* distortion induces, while at speed, a new *dynamic* eccentricity at some angle of lag with the original eccentricity. Since these two are generally at angles with each other, the plane of the resultant eccentricity is slightly different from that of the initial eccentricity and the rotor will now be rubbed in a slightly different spot. This shifting may proceed indefinitely. The vibration may get worse or the rotor may rub itself free.

Detecting a Rub

An irregular diagram of a rub on a large 1,800-rpm machine is shown in Fig. 1. Amplitude of vibration has been plotted in the direction of the phase angle between the vibration and a certain plane on the rotor. In this case, the rub wandered some 240 deg over the rotor, then contact ceased and the rotor returned to its original shape.

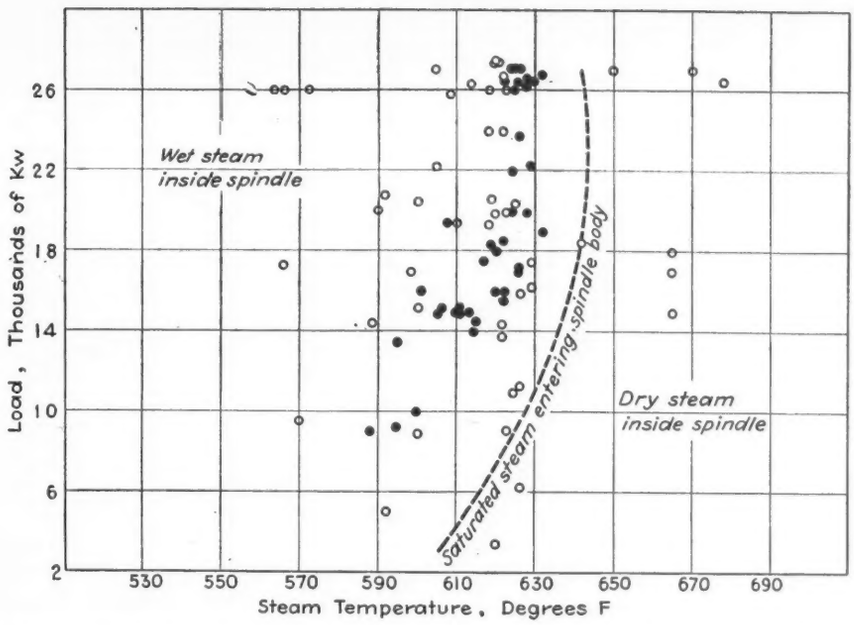


Fig. 3—Black dots show abnormal vibration occurring only when steam conditions are just right for a little condensation inside the rotor

(d) Before the steel industry could turn out large rotors in one piece, manufacturers of rotating machinery resorted to pressing or shrinking parts together. In the case of hollow rotors this was necessary anyway. Peculiar vibration phenomena can occur when, because of a sudden change in temperature, one part tends to expand differently from the other. A typical spindle construction, in which a light hollow rotor part is shrunk or pressed onto a heavy spindle end is shown schematically in Fig. 2. A sudden increase in temperature at *A* will tend to expand the thin hollow sleeve more rapidly than the more massive solid end. The result is a tendency to become loose.

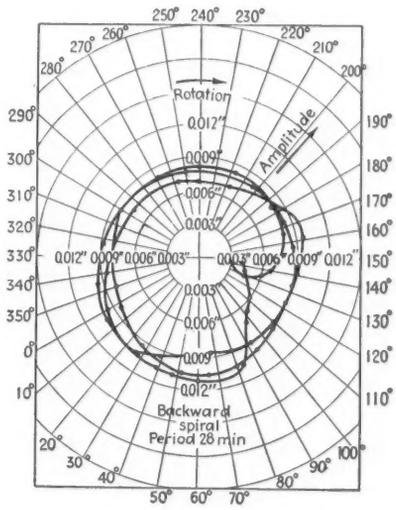


Fig. 4—Condensation inside a hollow rotor can cause eccentricity to move around in a peculiarly uniform and regular manner

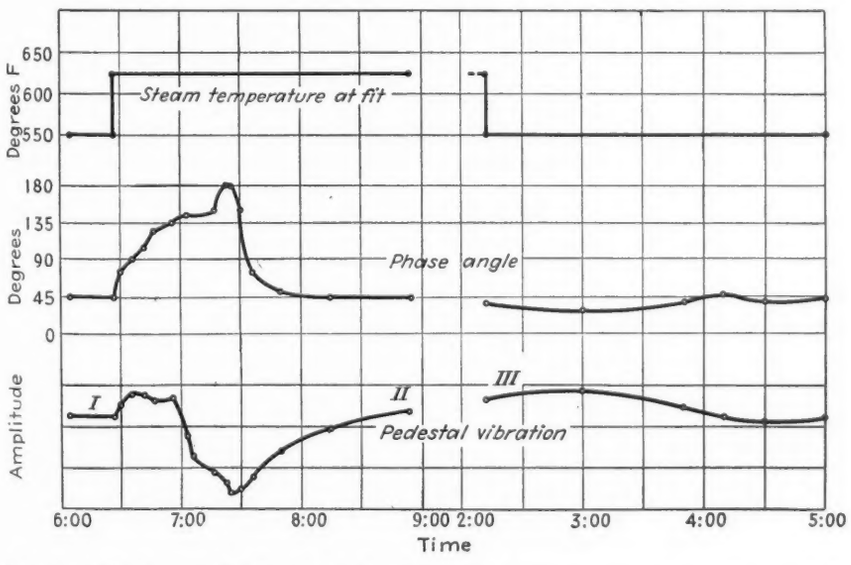


Fig. 5—Vibration amplitude and angle change when steam temperature at pressed fit rises for rotor of Fig. 2

The word "tendency" is used purposely because in the cases studied physical looseness apparently does not occur. Rather the rotor distorts due to a variation of heat conductivity across the fit.

These cases are characteristic in that, while a sudden increase in temperature may produce erratic vibration, a sudden cooling will merely make the fit tighter without any change in vibration.

Typical characteristics, measured on an old 30,000-kw machine, are shown in Fig. 5. As soon as the temperature is increased, a change in vibration occurs (I). This usually is accompanied by a change in the plane of

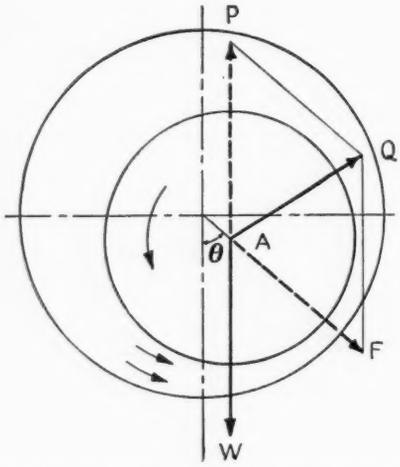


Fig. 6—Journals do not always stay still in bearings. The mechanism of "oil whip" is now well understood

eccentricity of the rotor. After a while, temperature of the heavy part has caught up with temperature of the light part and the vibration becomes normal again (II). When the temperature is suddenly reduced, there is no further change in the vibration except for a slight readjustment due to the change in temperature all along the rotor (III).

Temperature at Fits

If loose fits are suspected, it is well to determine if any change in operation that increases the temperature at the fit will produce a vibration spell. For one turbine, both an increase in load and a reduction in vacuum increased the temperature around the fit. Both these changes in operating conditions, when made rapidly enough, resulted in erratic vibration. By giving rotor parts an adequate fit pressure made uniform over the length of the fit, this type of trouble has been eliminated.

(e) Some turbine designs employ hollow rotors through which the steam flows. In these machines it is possible, under certain temperature and pressure conditions, to have a small amount of local condensation of water on the inside of the rotor. Under the action of centrifugal force this water moves to the most eccentric place on the rotor (at running speed). Here it will cause a thermal distortion. As in the case of a rub, this *static* distortion produces, at speed, a *dynamic* distortion which again adds vectorially to the original eccentricity with a certain angle of lag, so that the plane of eccentricity is shifted. The water now accumulates in this new plane. This shifting can go on continuously, provided the steam conditions and load are kept absolutely constant. The plane of eccentricity may go several times around the rotor circumference before a disturbance in the steam conditions breaks up the phenomenon, either by drying up the inside of the rotor, or by such an increase in condensation that the rotor is wetted uniformly.

The measured amplitudes of vibration of the shaft of an old 25,000-kw machine are plotted in Fig. 4, against the "high spot" (the direction of eccentricity on the rotor) at various times. In this case it took exactly 28 minutes for the eccentricity to go all around the rotor. The distortion wandered around the circumference of the rotor three times before a slight change in operating conditions broke the spell.

Interesting in this case is a plot, Fig. 3, made up for the same machine to show under what operating conditions erratic vibration occurred (the variation of steam pressure and vacuum are of minor influence). Black dots indicate shaft vibration above a certain minimum; circles indicate good operation. A saturation line has been plotted from measurements taken on the steam before and after it went through the inside of the rotor. The diagram shows clearly that a certain amount of condensation was necessary to produce severe vibration. But when the inside of the spindle is quite dry or very wet, the machine behaved normally.

This case was cured by mounting a thin diffuser-shaped sleeve inside the rotor. This sleeve made it impossible for the condensate to touch the rotor proper and because of its thin walls any variation in temperature of the sleeve itself could not manifest itself in distortion of the rotor.

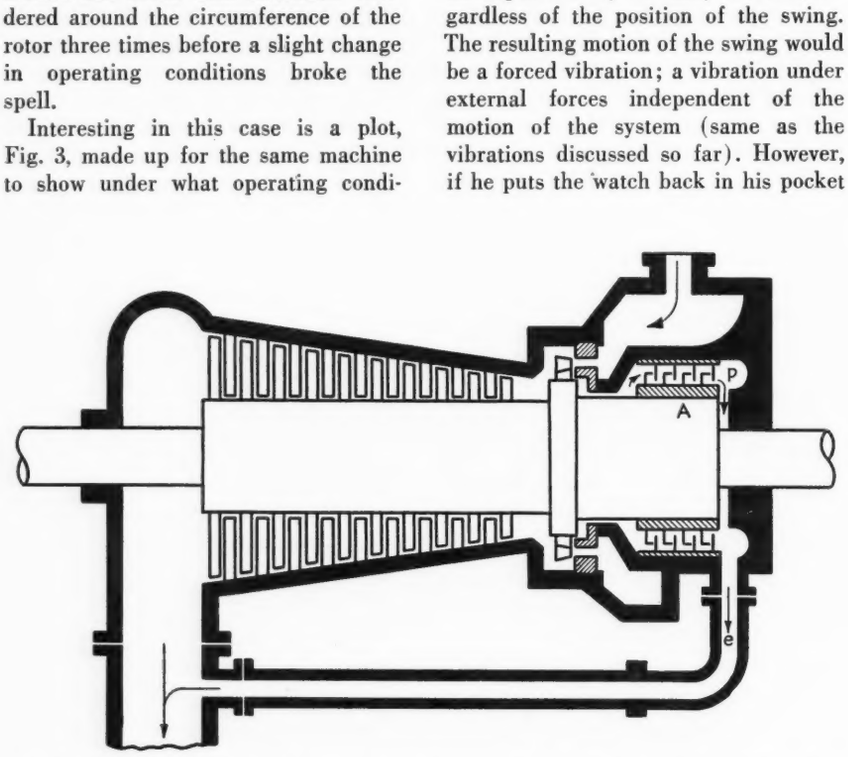


Fig. 7—Endwise reciprocating motion of the spindle resulted on this turbine from varying flow past axial-sealed dummies. Adding a small chamber in front of the equilibrium pipe cured the trouble permanently

Vibrations occuring at a natural frequency of the structural system are called *self-excited vibrations* or *vibrations with negative damping*. For a homely example to illustrate the difference between self-induced vibrations and forced vibrations due to unbalance discussed above let us think of a boy on a swing.

Suppose that the boy has an experimental nature. He looks at his watch and decides to give the swing an impulse every so many seconds, regardless of the position of the swing. The resulting motion of the swing would be a forced vibration; a vibration under external forces independent of the motion of the system (same as the vibrations discussed so far). However, if he puts the watch back in his pocket and behaves normally, he will give the swing an impulse whenever it is in a certain position. If he does this uniformly (so that for any given motion of the swing he moves his body always in a certain way), we may start to speak of "self-excited vibration." One can define a self-induced vibration as one in which the energy-supplying forces are determined by the vibratory motion itself.

Whether the boy pushes or not, motion of the swing has approximately the same period, the natural period. Since all he has to do to keep the swing going is to supply the small amount of energy dissipated by friction, the forces he exerts are small compared with the gravity forces and the inertia forces which determine the time period of the swing.

The term "vibrations with negative damping" becomes clear when one considers that while ordinary damping forces tend to let the motion die out, the forces supplied by the boy are of the opposite nature tending to increase the amount of motion.

One of the best known cases of self-induced vibration in rotating machinery is the so-called *oil whip*†, which can take place under certain conditions with rotors in copiously lubricated bearings. Professor Den Hartog‡ gives a particularly lucid explanation.

To understand the phenomenon, consider that in the bearing with a well-developed oil film, a radial force on the shaft produces a displacement somewhat out of line with the force, Fig. 6. For example, a rotor under its own weight W will assume an eccentric position making an angle θ with W. This means that P, the resultant force of the oil film on the shaft, is equal and opposite W.

Suppose that the shafts start whirling and that A is the instantaneous position of the shaft. Its centrifugal force F is not balanced by the bearing reaction P, rather there is a component Q left which tends to whirl the journal around in the direction of rotation.

The above explanation hinges around the assumption that the oil film is well developed and will behave the same as in the steady state case of gravity loading. The slower the whirl moves the more true this becomes. It has been found that when the whirl frequency is less than about one-half the running speed of the machine, oil whirl can develop. The whirl takes place at the critical speed of the shaft (its natural frequency) being determined by the flexibility and the mass distribution of the rotor (and the stator). All the bearing does is to supply the motive force.

The fact that in most horizontal bearings only the bottom 90 or 120 deg are used for bearing surface complicates an analysis. The cure for oil whip is generally accomplished either by reducing this arc of contact, or by increasing the bearing pressure by other means such as circumferential grooves in the bearing.

Induced Vibration

Press fits on shafts and internal hysteresis of rotors can induce vibration at the natural frequency***. It can be shown that the hysteresis forces will only excite this kind of vibration when the running speed is above the whirl speed, that is, above the critical speed of the machine.

A most interesting type of self-induced axial oscillation in some turbines was investigated by J G Baker of the Westinghouse Co. The machine in question, shown schematically in Fig. 7, had end-tightened dummies, A, so that the dummy clearance and consequently the steam flow through the dummy depended on the axial position of the spindle.

If one pictures an axial oscillation of the spindle, the variation of dummy flow results in an oscillation of the pressure p in back of the dummy. The amount of pressure oscillation and its phase angle with respect to the vibration depends on the dimensions of the equilibrium pipe e. In this particular case the pressure oscillations were such that when the spindle moved to the left the pressure against it was higher than when the spindle moved to the right. Therefore, over a whole cycle, there was a net energy input which excited the motion. The trouble was cured by adding a small chamber in front of the equilibrium pipe.

These examples cover the great majority of practical cases. There are, however, some other types. A particular instance is vibration due to rubbing or impact taking place at frequencies at a sub-multiple of the running speed. Here the critical speed must be near ½, ⅓ . . . of the running speed. As unbalance of the rotor increases for one reason or another and impacting results, the friction forces acting on the rotor tend to maintain a vibration at the critical speed. However, the timing of the impulses depends on the running speed. The resulting vibration is then a combination of running speed and sub-multiple frequency.

† "Shaft Whipping due to Oil Action in Journal Bearings," by B L Newkirk, General Electric Review, 1925, page 559.

‡ "Mechanical Vibrations," by J P Den Hartog, McGraw-Hill Book Co, 1934, page 294.

*** "Internal Friction Theory of Shaft Whipping," by A L Kimball, General Electric Review, 1925, page 559.

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Stoker Flexibility Asset During Coal Strike

C W BALDWIN, *American Engrg Co*

▶ LAST APRIL'S COAL STRIKE forced thousands of operators to mix rapidly diminishing stocks of bituminous coal with fuels such as coke breeze and anthracite or swing over to the substitutes completely. Results of "crisis" experiences, in plants with multiple-retort underfeed stokers, cast new light on fuel-burning characteristics and indicate some possibilities for experiment.

Typical of these experiences is that of a government plant equipped exclusively with air-cooled continuous-ash-discharge stokers. When the supply of bituminous disappeared, operators swung over to anthracite and operated for several weeks on this fuel. While capacity was reduced, the plant kept going satisfactorily until the strike ended and bituminous again became available. Faced with similar conditions, an industrial plant with water-cooled stokers burned a mixture of 75% anthracite and 25% bituminous. Even prior to the strike, a number of central stations receiving coal by barge at tidewater experimented successfully with mixtures of two fuels on multiple-retort stokers, to bring about a reduction in fuel cost. In such cases, steam sizes of anthracite were mixed with bituminous at the coal unloading piers and the mixture delivered to the various plants by barge.

Of particular interest is the experience of a large eastern sugar refinery. At this plant, 11-retort, double-roll-

(Continued on page 132)

TYPICAL ANALYSES OF FUELS

	Pa. Bituminous ¾-in. nut & slack	*Anthracite No. 4 Buckwheat*
Volatile matter	25–28%	10.47%
Fixed carbon	65–57%	69.75%
Ash	8–9%	11.28%
Moisture	2–6%	8.5%
Btu (average, as fired)	13,850	11,700

Low-Cost Flue-Dust Sampler

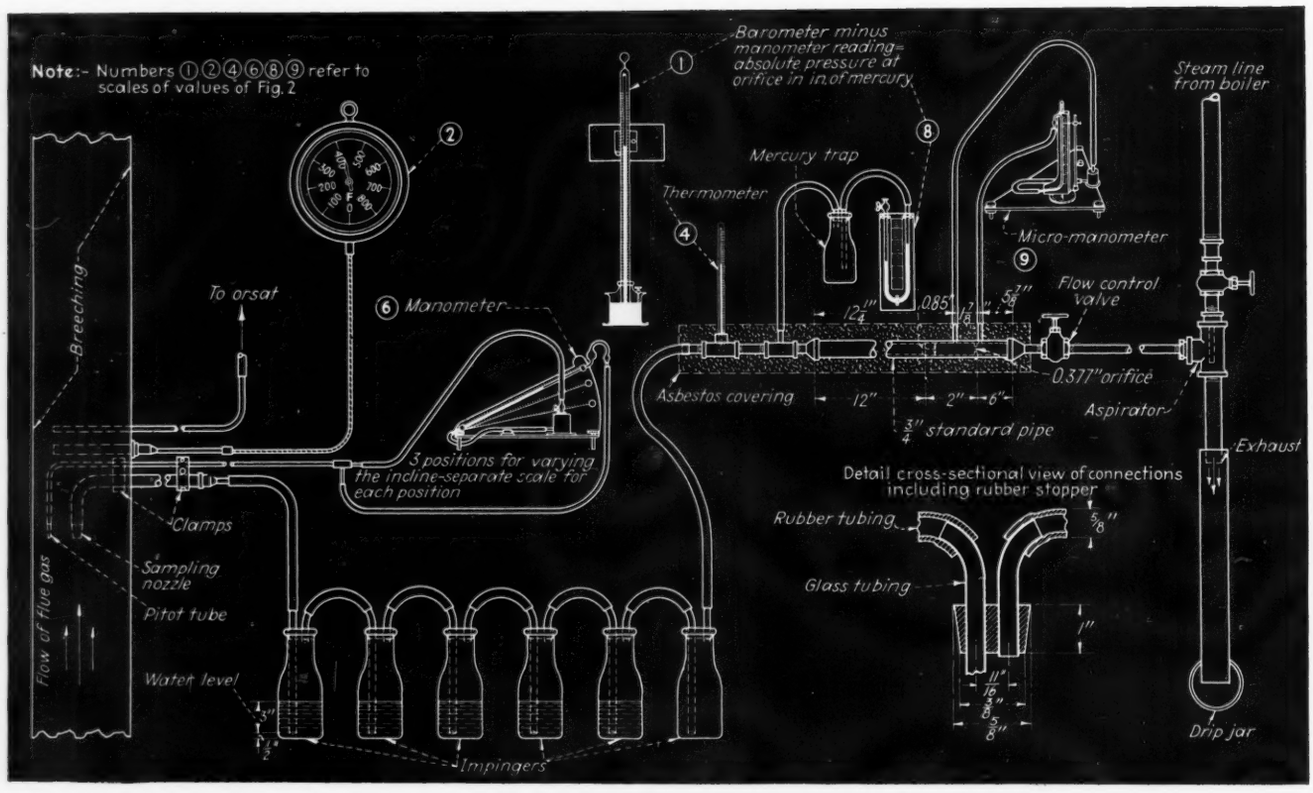


Fig. 1—Milk bottles are the heart of this dust-sampling device that gets even the finest particles of soot. Standardized routine and good instrumentation assure a fair degree of accuracy

One important product of a very complete atmospheric-pollution survey conducted by the WPA in Chicago is a simple dust-sampling device and technique

▶ BY TRACKING DOWN air pollution to its sources with quantitative as well as qualitative analysis, the smoke-prevention problem loses most of its vagueness and begins to take on a tangible aspect. Finding where pollution originates and the causes of each component of the total takes a long step toward minimizing nuisance.

In addition to studies of ultraviolet-ray impairment by smoke, visible emission surveys and the like, a Chicago WPA project has checked a large number of plants for amount of solids discharged from the stack. These included a wide and comprehensive number of classes of combustion equipment, practically every type to be found in the city.

This article deals only with a simple sampling device and test procedure that enabled portable equipment to be set up quickly in a large number of plants by a small test crew with little technical training. The equipment is capable of collecting a 50-grain (about 0.1 oz) sample in an 8-hr working day. The device collects more than 90% of the dust that enters the sampling nozzle.

Existing equipment such as bag testers, commercial impingers, cyclones, thimbles and even an electric precipitator were deemed not completely satisfactory for one reason or another. Stack temperatures found were too high for bag testers, which suffered from dehydration and scorching. The bags also pass some of the fines. Commercial impingers do not collect a sufficiently large sample; multiple impingers required excessive pumping apparatus to handle the air flow. Cyclones pass an appreciable part of the smaller soot particles. Thimbles collect only a small sample and require considerable skill on the part of the test crew. An electrostatic precipitator intended for atmospheric dust was available but it would not collect the coarser particles of grit and flyash.

The simple apparatus shown in Fig. 1 has been found to meet practically all the stipulated requirements. Parts required are (1) pitot tubes to measure

Assistance in preparing this article was furnished by the personnel of Work Projects Administration Official Project 300 51 sponsored by the Chicago Department of Smoke Inspection and Abatement. Messrs H D Blackwell, Loyd Stowe, Milton Press, Harold Swanson and Dr Sidney Bloomenthal were chiefly responsible for development of the described equipment.

gas velocity in breeching, (2) sampling nozzles, (3) separating device made from milk bottles, glass tubing and rubber hose, (4) orifice meter, (5) water and mercury manometers, (6) thermometers, (7) vacuum pumps or aspirators. In addition to the sampler itself, breeching baffle plates, a draft gage, an orsat and a means of weighing coal completed the test kit.

Sampling Apparatus

The sampling apparatus itself consists of a nozzle through which the gas is drawn and a number of impinger bottles which retain the solids in water while allowing the gas to pass through to the aspirator. The sampling nozzle used in the Chicago tests has a diameter of 0.657 in. Smaller nozzles accommodated high-velocity cases; larger ones were needed to get adequate quantity of sample when the velocity in the breeching was low. With all nozzles, velocity of gas in the sampling tube was maintained equal to that in the breeching.

Each impinger bottle is fitted with two glass tubes, one of which extends down to within a half inch from the bottom of the bottle. The outlet tube of each bottle is connected by rubber tubing to the inlet of the next. The first five bottles are filled to a depth of 3 in. with distilled water. The sixth bottle contains no liquid. The separating effect depends in part on the high-velocity impact and the washing action of the water and in part on the wetting effect of the vapor above the liquid level.

Measurement of the amount of gas sampled is accomplished by a manometer across the orifice and a mercury U-tube reading inches of mercury vacuum upstream of the orifice. Temperatures of gas in the duct and at the orifice are also taken.

A drip jar at the outlet of the exhausting device, Fig. 1, indicates the presence of dust not caught in the bottles, thus signalling failure of some part of the equipment to the operating crew.

Tests Require Care

Location of sampling point is an important consideration, (see POWER, November 1939, page 68). Vertical stacks or flues are better than horizontal because of settling in the latter. Crosswise vertical baffles were set across the full width of horizontal breechings to dam the drift of settled dust.

Before test, the net cross-sectional area of breeching or stack is divided into zones of approximately equal area so that a single sampler can be moved from center to center of the zones remaining in each for an equal time interval. (See ASME tentative test code for dust collectors.)

When wide ranges of firing conditions or gas flow exist, the accuracy of the sampling procedure is increased by reducing the duration of the sampling interval and increasing the number of complete traverses of the breeching cross section. In traversing the stations, the sampling velocity is varied to correspond with the velocity in the duct at each point so that the dust collected during an entire run represents a weighted average.

To hold the sampling velocity equal to that in the breeching at the point of sampling requires measurement of five quantities and a calculation by formula or chart. The information required is (1) velocity pressure by pitot tube at the sampling point, (2) barometer reading, (3) temperature of the gas at the orifice, (4) temperature of the gas in the breeching and (5) absolute pressure immediately upstream from the orifice.

An alignment chart, Fig. 2, provides a rapid method of calculating proper adjustment of the regulating valve shown in Fig. 1. Having the five measured quantities listed above from the instruments numbered in Fig. 1, the required pressure drop across the orifice can be found in a few seconds. Numbers on chart scales correspond to numbers on instruments in Fig. 1 from which the reading is obtained. It is only necessary to subtract the mercury U-tube (8) reading from the barometer (1) reading to get absolute pressure at the orifice to enter Scale 8 of Fig. 2. Other measurements are used directly.

Use of the Chart

The chart is designed for use with a 0.657-in. sampling nozzle and a 0.377-in. orifice. Within certain limits, it can be used directly for any sampling nozzle provided the proper factor is used in connection with the orifice flow. Changing orifices is usually inconvenient and the same chart can be used with the 0.377-in. orifice and other sizes of sampling nozzle by multiplying the orifice-differential pressure obtained from Scale 9 of the chart by a factor. For 1/8-in. standard pipe (machined to 0.000396-sq-ft entrance area) multiply reading on Scale 9 by 0.03, for 1/4-in. pipe (0.000722-sq-ft), by 0.1, for 3/8-in. pipe (0.001326-sqft), by 0.32, and for 1-in. pipe (0.006-sq-ft), by 6.5.

When velocity pressures are beyond the range of Scale 6, the scale can be considered as enlarged ten times, that is, the scale runs from 0.05 to 5.0. The orifice-differential pressure reading from Scale 9 is then multiplied by ten before using.

After determining orifice-differential pressure from the chart for a specific

TABLE I—PARTIAL RESULTS FROM A TYPICAL OFFICE BUILDING

1	2	3	4	5	6
Bottle No.	*Date Dust Collected*	*Duration of Run in Hrs*	*Weight of Dust Collected Grams*	*% Combustible*	*% Ash*
(1) +325M	11–9–39		0.8355	58.50	41.50
−325M	11–9–39		0.3316	52.40	47.60
(2) +325M	11–9–39		0.0174	71.21	28.79
−325M	11–9–39		0.0330	84.08	15.92
(3) +325M	11–9–39		0.0102	53.65	46.35
−325M	11–9–39		0.0235	90.47	9.53
(4) +325M	11–9–39		0.0088	34.05	65.96
−325M	11–9–39		0.0220	97.64	2.36
(5) +325M	11–9–39		0.0028	60.00	40.00
−325M	11–9–39		0.0120	94.92	5.08
(6) +325M	11–9–39		0.0029	94.74	5.26
−325M	11–9–39		0.0025	88.00	12.00
Washings from gas collector & tube					
+325M	11–9–39		0.0874	74.40	25.60
−325M	11–9–39		0.1471	41.05	58.95
Totals		6.5	1.5367		

7 — Volume of dry gas sampled, cu ft at 60 F, 30-in. Hg	465.2
8 — Weight of dry coal burned during run, lb	2948.
9 — Grains suspended dust per 1000 cu ft at 60 F, 30-in. Hg	50.8
10 — Dry Coal converted to suspended dust, %	0.378

sampling point, the correct differential is held by adjusting the regulating valve. Then the sampler is moved to the next point, a new differential is obtained and the point sampled for an equal period of time, until the traverse is complete.

At the completion of the run, dust in the sampling pipe and tubing up to and including the connections between bottles is thoroughly cleaned out by washing into a separate bottle.

Size Analysis

When a run is completed, all bottles are capped, labeled and sent to the central laboratory for filtering and drying. Contents of each bottle are first poured through a 5-in. diameter, 325-mesh (Sargent) screen into a porcelain evaporating dish. Since the object of the Chicago tests was to conduct a very broad investigation of flue-gas solids, the plus-325- and minus-325-mesh samples for each bottle were separately dried and weighed, tar was extracted by dissolving in chloroform, weight loss on ignition was determined and all these results coordinated with coal analyses. Partial results for a typical office building are shown in Table I.

It should be recognized that passing combustion gases containing entrained flyash through water permits sulphur-dioxide to react with the oxides of alkaline earths and alkalis contained in the ash. This reaction causes an increase in the weight of total dust reported as compared to actual conditions at the point of sampling. This increase is in a direction opposite to the decrease produced by the fact that this collector, as well as other collectors, has a collection efficiency less than 100%. Thus these factors tend to be compensatory. Further research is planned in the use of this collector using non-aqueous liquids as the collecting media.

The art of conducting dust-loading tests is still in the "Model T" stage of development. All present methods are still crude and cumbersome. The method presented is submitted for public information with the hope that other investigators will continue toward the ultimate aim of a simple dust-loading test method.

Dust loadings were considered the essence of the entire investigation. Individual plants were entered without making any change whatsoever in the operating conditions which might affect dust loadings. It is believed that operators did not exert any unusual precautions while the testing was in progress. On a few occasions where abnormal dust loadings were recorded, suggestions were made to operators as to changes in selection of fuel or operating conditions after which additional dust-loading tests were made to determine degree of improvement. The results along these lines proved highly successful.

Development of the flue-dust sampler is but a single phase of a broad fact-finding investigation, results of which will be made available to interested organizations. Definite established data as to the nature, composition and effects of contaminants in the air may prove of great value not only to Chicago authorities but to many private firms as well. The interrelated studies also cover abstraction of scientific literature and codification of legal opinions and decisions affecting air pollution such as might be of interest in similar cases.

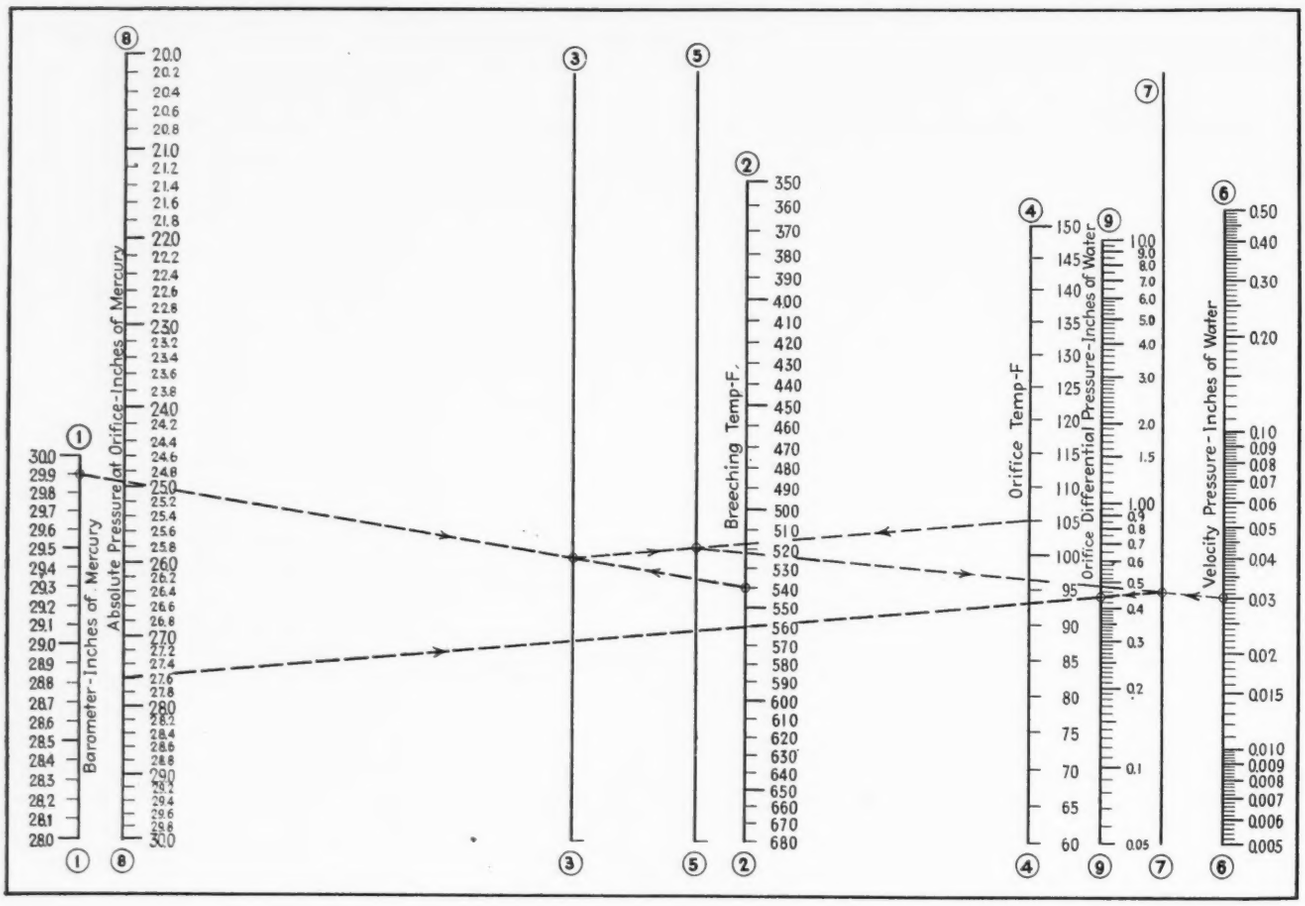


Fig. 2—Graphical chart quickly calculates proper orifice differential pressure to maintain velocity in the sampling nozzle equal to that in breeching or stack. Example shown starts on Scale 1 and finds required orifice differential on Scale 9. Barometer, 29.9 in. Hg; breeching temperature, 540 F; orifice temperature, 105 F; velocity pressure from pitot tube, 0.03 in. water gage; absolute pressure at orifice, 27.6 in. Hg; hold orifice differential at 0.44 in. water gage by adjusting control valve of Fig. 1

The Eyes Have It

Dean M Warren, lighting engineer, Nela Park Engineering Dept, General Electric Co, shows why vision must be protected industrially in the best interests of employee health, safety, comfort and efficiency—and tells just how to do it

▶A FEW YEARS AGO, factory managers, referring to employees, spoke of them as so many "hands." Today, however, with the decline of handcrafts, the term "hands" has fallen into disuse. Modern skill is now recognized as mental and not manual. Hundreds of industrial processes, when properly studied and analyzed, depend almost wholly upon visual judgment. Industrially the eyes have it all their own way. Skill today is almost entirely a matter of visual quickness and keenness, requiring lighting of proper quantity and quality.

The amount of light required for a particular task depends upon the visual severity of that task. As may be expected, there is a definite relationship between the light available for seeing an object, the size of the object seen, the contrast of the object with its background, and the time available for seeing that object, or, the speed at which the object is moving. For example, when the object is large, the contrast great, and the time for observation ample, the visual task is easy and relatively little light is needed.

The following table shows footcandle values representative of various seeing tasks. These values may seem low when compared to the 500 to 9000 footcandles of outdoor daylight; actually they represent practical steps toward the much higher values that are more nearly ideal.

Operation	*Footcandles*
Engine Room	
Boilers, coal and ash handling, storage, battery room	5
Auxiliary equipment, oil switches and transformers	10
Switchboards, engines, generators, compressors, blowers	15
Machine shop	30–50
Engineers office	20
Drafting room	30–50

Scientific lighting design requires accurate measurement of the light. The units used in measuring light follow naturally from the various steps involved in seeing. An object is not seen by the light which comes directly from the light source to the eye, but by the light which goes first to the object and is then reflected to the eye with its message regarding the size, shape, color and other details. The lumen and the footcandle are the two terms most used.

Fig. 1—Vest-pocket light meter is invaluable to engineer in checking light conditions

The lumen is a unit of quantity in light, just as a bushel is a unit of quantity in measuring apples. It is the amount of light intercepted by a surface one foot square, every point of which is one foot from a source of one candlepower. Since the lumen is a unit of quantity, the amount of light it represents will not be changed by spreading it over a greater or lesser area, just as the bushel of apples spread out under the tree is just as much a bushel of apples as though it were in a basket.

The footcandle, on the other hand, is the unit of illumination *intensity*. It is the result, whereas the lumens represent the cause. It is defined as the illumination on a surface one foot square on which one lumen is uniformly distributed, or the illumination produced at a surface, all points of which are at a distance of one foot from a source of one candle.

Since an average illumination of one footcandle results when one lumen falls on one square foot of surface, the number of lumens that must be provided on the working plane to produce a desired level of illumination can be found by simply multiplying the desired footcandles by the number of square feet to be illuminated. This important relation forms the basis of the widely used lumen method of designing lighting installations.

There is no more need to guess about the level of lighting than there is to depend on the sense of feeling to gage temperature. A direct-reading instrument called a light meter tells at a glance the amount of light available (Fig. 1).

The meter is rectangular in shape and of such a size that it can be carried easily in the vest pocket. It is designed so that the scale face is at right angles to the light-sensitive cell. The instrument has a full-scale reading of 75 footcandles, and, by the use of a 10 to 1 multiplying plate, readings up to 750 footcandles may be taken.

The footcandles available for seeing

DIMENSIONS, ELECTRICAL DATA, AND LUMEN OUTPUTS OF FLUORESCENT LAMPS

Lamp size	*18-in.*	*18-in.*	*24-in.*	*36-in.*	*48-in.*	*58-in.*
Nominal lamp watts...	15	15	20	30	40	85 RF
Circuit voltages.....	110–125	110–125	110–125	199–250 / 110–125	199–250 / 110–125	199–250 / 110–125
Over-all length.....	$17\frac{25}{32}$″	$17\frac{25}{32}$″	$23\frac{25}{32}$″	$35\frac{25}{32}$″	$47\frac{25}{32}$″	57½″
Diameter.....	1″	1½″	1½″	1″	1½″	1¼″
Rated lab life hrs.....	2000	2000	2000	2000	2000	3000
Lumens — daylight....	450	450	660	1110	1600	....
Lumens — white.....	525	525	760	1320	1880	....
Lumens — bluish white	....	....	....	....	....	4250

are easily checked by means of the light meter, but the quality of the lighting cannot be so checked. This includes such considerations as glare and its effect on the eyes and seeing, reflected glare, diffusing and shadows, all of which enter the seeing problem.

Probably the most apparent and at the same time the most vicious factor of quality is that of glare. It is the most obvious sign of needed lighting improvements. Glaring lights are hazardous to eyesight and are wasteful because they reduce visibility.

The cost of glare, measured by the waste of footcandles required to overcome reduced visibility due to glare, is shown in Fig. 2. At this machine a glaring local light, used to supply additional footcandles on the work, causes the pupils to narrow down automatically, thus restricting the opening for "seeing" light to enter. From 40 to 80% of the useful light is wasted counteracting the effect of glare.

Reflected Glare

Reflected glare, that is, brightness reflected from shiny work surfaces, may prove even more annoying because the eye has no natural protection against it. This calls for an intelligent analysis on the part of the lighting engineer and dictates choice of equipment and its location so as to insure both adequate diffusion and proper direction of light upon the work. Glare may result from (1) lighting equipment which does not confine the light to the proper angle, but directs an excessive amount to the eyes, (2) units equipped with lamps that are too large for them, (3) units with excessively high brightness at the angles reflected to the eye by shiny metal, (4) improper location or adjustment of equipment which permits bright reflections of the source to reach the eye.

It is usually desirable to provide even illumination over the entire working area, eliminating shadows formed as a result of inadequate diffusion of light, wrong placement of light sources, insufficient number of sources, and use of supplementary lighting with no general illumination. If even lighting is accomplished no worker is unfairly penalized. Fig. 3 shows conditions which arise when lights are spaced too widely apart. The effect of "roller coaster" lighting is obtained and the worker in the 5-footcandle area is under strain. The condition is remedied, Fig. 4, where the lights are placed closer together to give better light distribution.

Just as a large portion of the crude stone must be cut away to produce a finished gem, so the efficiency of a lighting system must often be reduced to gain a comfortable diffused lighting.

There are seven fundamentals of performance usually considered by those experienced in the selection of lighting equipments. They are: (1) efficiency, (2) absence of direct glare and reflected glare, (3) softness of shadows, (4) satisfactory distribution of light at various angles, (5) ease of maintenance, (6) sturdiness of construction, and (7) cost. Naturally the relative importance of these varies with different applications. In choosing between two or more units, the buyer should be gov-

(Continued on page 112)

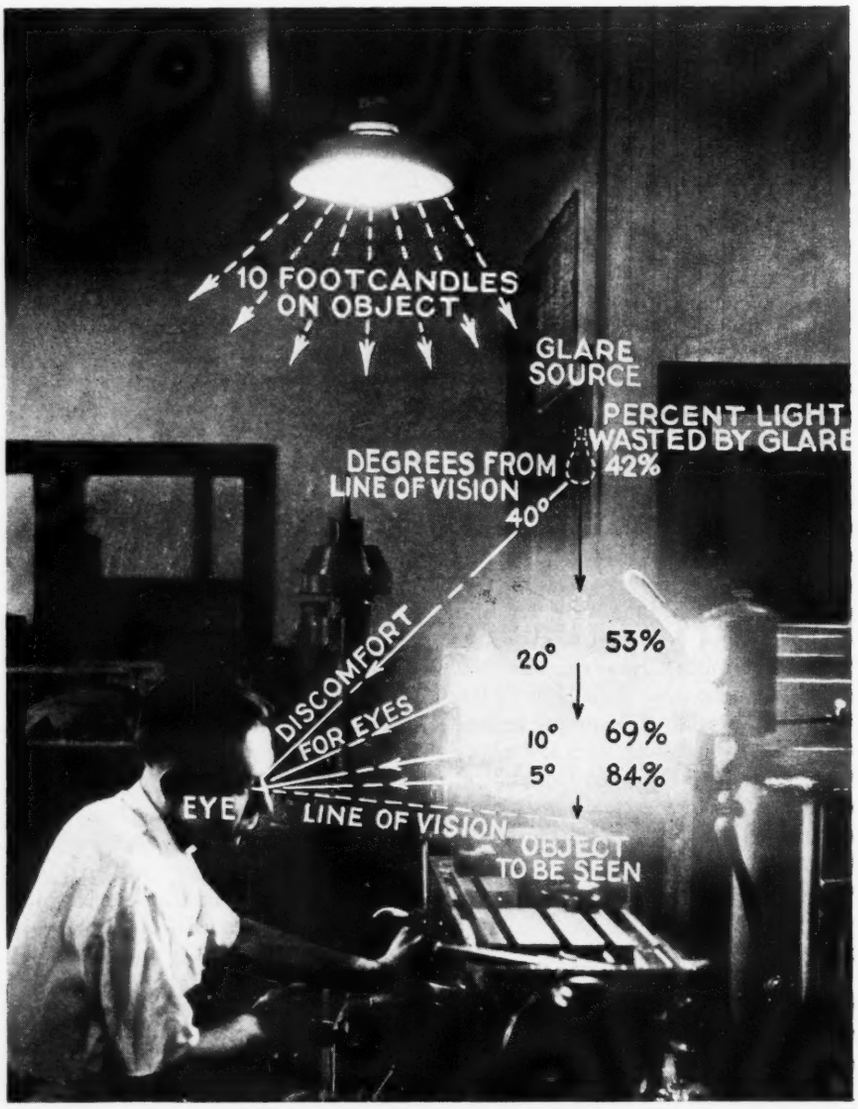


Fig. 2—An old supposition that an extra, glaring, local light gives more illumination to work with has been scotched. Amount of light wasted is much more than that provided by glaring lamp

POWERED BY AC

By F A ANNETT
Associate Editor

Ever since Nicola Tesla developed the alternating-current, polyphase induction motor in 1888, designers have struggled with the unruly brute to harness it for power drives. Their efforts have not been 100% successful, however, for there are still many jobs that can be taken on solely by direct-current motors. The simple, rugged, polyphase, squirrel-cage unit, with no moving contacts, looks like the answer to the prayers of both designers and users, but in practice it falls shy of the ideal.

Putting resistance in series with the armature of a direct-current shunt motor slows it down, while field resistance speeds it up. Not so with an induction motor. Its speed is fixed by the number of poles in its stator winding and by line frequency, and there isn't much you can do to change either. Stator windings can be regrouped to give two speeds, one double the other, not generally a desirable combination. Characteristics at either speed are not as satisfactory as they are for a single-speed motor.

High efficiency, high starting torque and low starting current are desirable habits for every motor, but they can't be had in a simple squirrel-cage machine. High efficiency requires a low-resistance rotor winding, but this produces low starting torque. A rotor winding of comparatively high resistance gives high starting torque but low efficiency.

To satisfy two of the three desirables, manufacturers have developed many designs of single- and double-squirrel-cage windings to give high efficiency and high starting torque. Six standard types are defined and listed in the National Electrical Manufacturers' Association Standards, and there are more. If these cannot meet starting requirements, a wound-rotor motor must be selected.

Most power systems suffer from effects of low lagging power factor of induction motors. Power-factor and torque characteristics of these machines get worse as speed goes down. However, power factor of synchronous motors can be controlled and made leading to correct pf of induction units.

The wide range of speed obtained with direct-current machines is impossible with alternating-current motors. To obtain even limited speed adjustment we have to use commutators and speed-regulating sets, commutators and slip rings, and other complicating devices. In many cases, it is necessary or more economical to convert alternating to direct current and install dc machines.

Single-phase motors have to be specially designed to make them self-starting. Result has been the series, shaded-pole, split-phase, capacitor, repulsion-induction, and repulsion-start-induction-run motors. Each type is built in several designs to meet starting and other requirements, further complicating the problem of ac-motor application.

This picture is not quite as complicated, however, as it may appear, because about 80% of industrial applications above one horsepower can be met by polyphase, general-purpose, squirrel-cage induction motors. But the operating engineer must have on tap knowledge of all types. "Powered by AC," POWER's 30th special section, explains how alternating-current motors operate, how to select, connect and reverse them, and most important, how to locate troubles and fix them.

Squirrel-Cage Motors

► ALTERNATING-CURRENT MOTORS are built in many designs. These include polyphase *squirrel-cage*, *wound-rotor*, *synchronous* and *commutator types; single-phase*, *split-phase*, *capacitor-start*, *capacitor-start-and-run*, *shaded-pole* and *commutator* types in single-phase designs. Each of these will be considered in turn, but to start let's study the polyphase squirrel-cage induction motor.

The stationary part of an induction motor is called the *stator*, the rotating member the *rotor*. The stator, Fig. 1, has insulated windings distributed in slots around the inner rim of a laminated-iron core. In a 3-phase motor the stator has three windings; in a 2-phase, two windings. These windings connect to the power circuit and correspond to the armature windings of a direct-current motor.

The rotor, Fig. 2, comprises a laminated-iron core with a bar winding in slots. These bars connect to rings at each end to form a structure that looks something like a squirrel-cage. This winding has no connection to the power circuit and the current in it is induced. It is from this feature and the rotor winding that the motor gets its name of induction squirrel-cage.

Induction-Motor Operation

An induction motor operates on the same fundamental principle as a dc motor, but the story takes another twist when we consider how current is produced in the rotor winding. In an induction motor, the magnetic field produced by the stator winding revolves around the inner surface of the stator core. The rotating magnetic field generates a current in the rotor bars that causes the rotor to revolve with the magnetic field. Let's see exactly how this happens.

For simplicity, consider a 2-phase motor, even though a majority of polyphase motors operate on 3-phase power circuits. A 2-phase generator has two windings so placed that, when the voltage in one is at a maximum, that in the other is at zero. This condition is represented by the curves *A* and *B*, Fig. 3. Curve *A* shows the voltage generated by one winding in the generator and curve *B* the voltage in the other.

In a 2-phase motor, there are two groups of windings indicated as A_1, A_2, A_3 and A_4 for one phase, and B_1, B_2, B_3 and B_4 for the other, Fig. 4. Assume that voltage is applied to the windings, Fig. 4, at instant *a*, Fig. 3. At this instant, *A* voltage is at maximum and *B* zero. This would give maximum current in *A*-phase conductors, Fig. 4, and zero in *B* conductors, as shown. Consider the current as flowing away from the reader in A_1 and A_3 groups of conductors and toward the reader in A_2 and A_4 groups. This would create a magnetic field of direction and polarity indicated.

At instant *b*, Fig. 3, voltage in *A* phase has decreased, and that in *B* phase increased until they are equal and in the same direction. Applying these voltages to the two windings gives the effect, Fig. 5. Current in the *A* and *B* conductor groups produces a magnetic field that spreads out to include all conductors having current in the same direction. This action causes the magnetic field center to shift clockwise from the middle of the *B* groups to between the *A* and *B* groups.

In Fig. 3, at instant *c*, *A* voltage is at zero, and *B* maximum, which if applied to the motor windings gives the conditions of Fig. 6. Current in winding *B* is at maximum, zero in *A*, and the magnetic-field center moves clockwise to the center of the *A*-conductor groups.

Going back to Fig. 3, we find that at instant *d* *A* and *B* voltages again are equal, but *A* has reversed. This reverses the current in *A* conductors of the motor, as in Fig. 7. Now the magnetic field is produced by the current in two windings, which causes the *N* and *S* poles to take a position again between the *A* and *B* conductor groups. At instant *e*, Fig. 3, voltage *A* is again maximum, but reversed from that at instant *a*, and *B* is zero. Therefore, current distribution in the motor windings, Fig. 8, will be the same as in Fig. 4, but reversed in the *A* conductors. The magnetic field has again moved in a clockwise direction. What happened in Figs. 4 to 8 is the same as if current had flowed in *A* conductors only, and the stator had been revolved 90 deg. Instead of revolving the stator, we are able, by using a second winding and a 2-phase current, to do the job electrically.

Now, assume that a rotor, with bar conductors in slots on its surface, is placed in the stator, Fig. 9. With the rotor stationary the magnetic field in the stator will revolve past the rotor conductors and generate a current in them. The magnetic field rotating clockwise past the conductors is equivalent to making the field stationary, and moving the conductors counter-clockwise. Applying the rule for an electric generator, Fig. 10, page 88, "Powered by DC," February POWER, to the rotor conductors. Fig. 9, gives a current

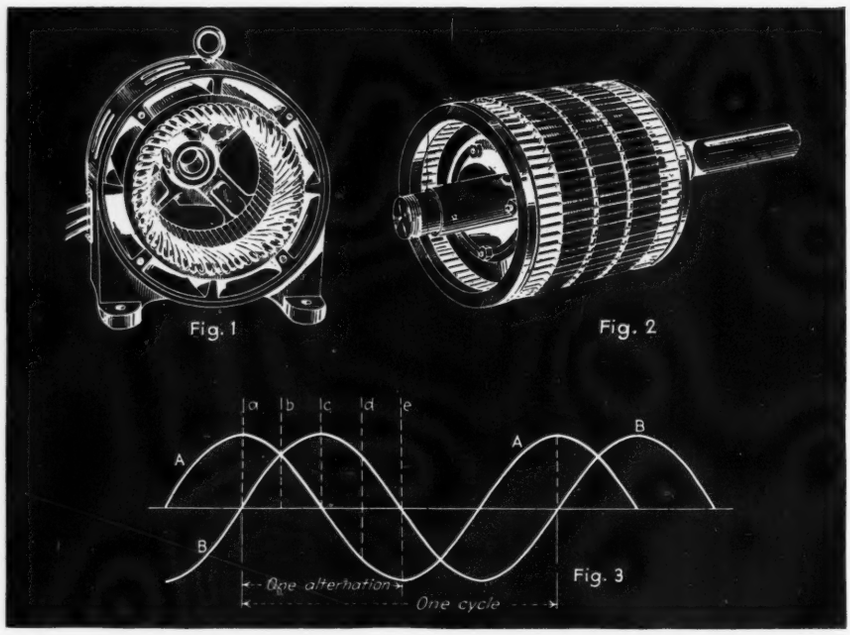
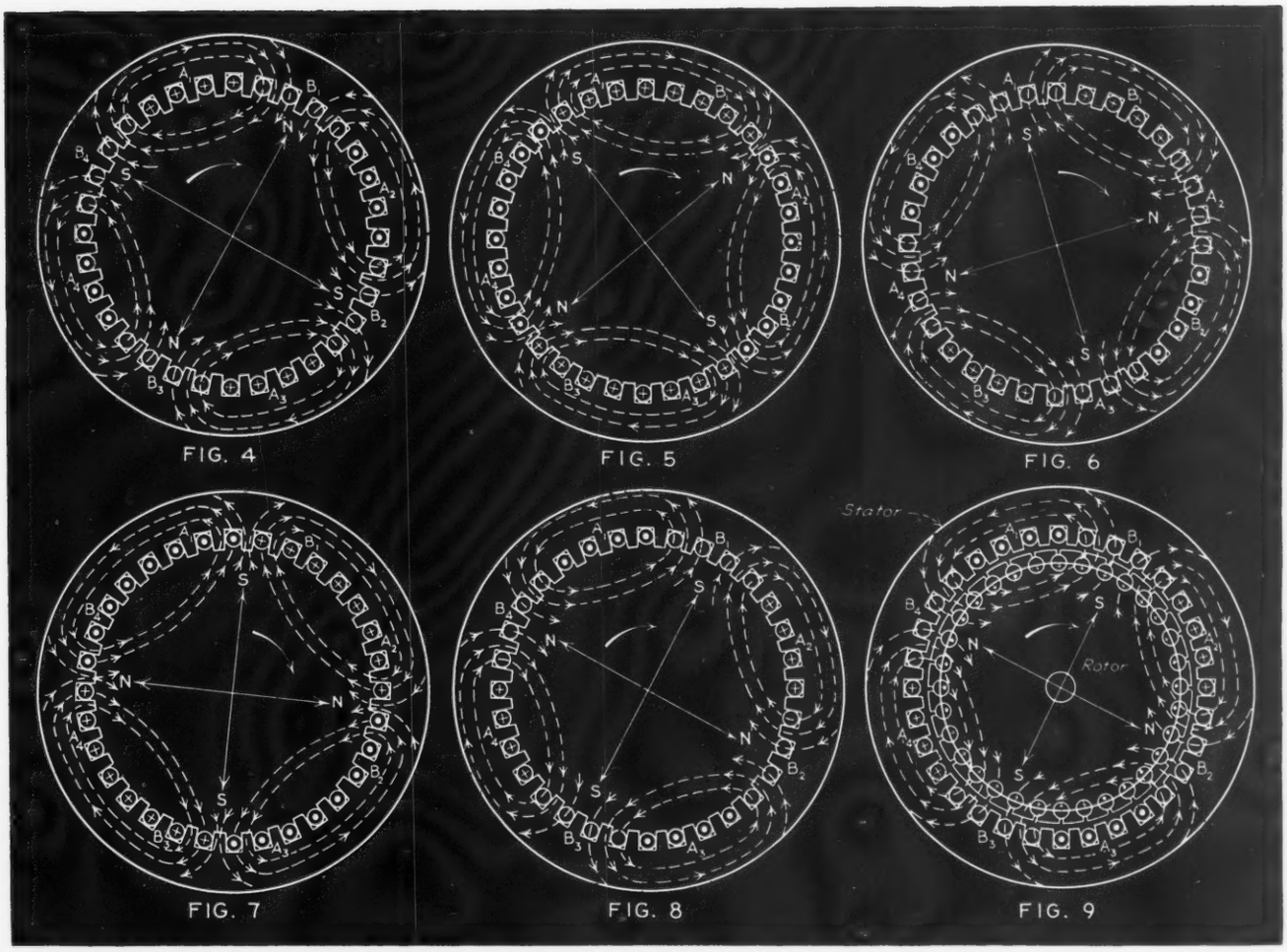


Fig. 1—Stator of an induction motor. Fig. 2—Squirrel-cage rotor of an induction motor. Fig. 3—Two-phase voltage or current curves



Figs. 4 to 8—How the magnetic field in an induction-motor stator can be made to rotate when its windings are connected to a 2-phase circuit. Fig. 9—Direction of current generated in a rotor winding shown by dots and crosses on the rotor bars

direction indicated by the dots and crosses. If we apply the rule for direction of motor rotation, Fig. 12, on the page just mentioned, to current direction in the rotor conductors and the direction of the magnetic field, we will find that the rotor will turn in the same direction as the stator magnetic field.

With the rotor stationary, the magnetic field will move past the rotor conductors at a rate determined by power-circuit frequency and number of stator poles. Let us see how fast this is.

The cycle of events followed through, Figs. 4 to 8, covered one alternation, Fig. 3. During this period the magnetic field moved one pole space. For example, in Fig. 4, N poles are opposite B_1 and B_3, and in Fig. 8 they have shifted in clockwise direction to B_2 and B_4. We may then draw the conclusion that when the current passes through one alternation the stator magnetic field shifts one pole space.

Frequency of an alternating-current circuit is expressed in cycles per second, one cycle equaling two alternations, Fig. 3. Then, on a 60-cycle circuit, there will be $2 \times 60 = 120$ alternations per second, or $120 \times 60 = 7200$ alternations per minute. Since the magnetic field moves one pole space for each alternation, in a 4-pole machine the magnetic field will make a complete revolution of the stator in 4 alternations. Thus, the magnetic field of a 4-pole motor will make $7200 \div 4 = 1800$ rpm.

Synchronous Speed

We may then write the rule for speed of magnetic field as equal to 120 times frequency (cycles per second) divided by the number of poles. In a 4-pole, 60-cycle motor, speed of the magnetic field will be $120 \times 60 \div 4 = 1800$ rpm. On a 25-cycle circuit the speed will be $120 \times 25 \div 4 = 750$ rpm. We may also write this rule as: number of poles equals 120 times cycles per second divided by speed. At 60 cycles and 1200 rpm, the motor will have $120 \times 60 \div 1200 = 6$ poles. The speed of the magnetic field is known as the *synchronous speed* of the motor.

If the 4-pole stator winding, Fig. 9, is connected to a 60-cycle circuit and the rotor is held stationary, the magnetic field will revolve past the rotor conductors at 1800 rpm. Under these conditions, a maximum current is generated in the rotor conductors at line frequency of 60 cycles per second. If we drive the rotor at 1800 rpm, the speed of the magnetic field, its conductors will not cut any of the magnetic lines and no current will be generated in them.

Since there is no current in the rotor conductors no turning effort (torque) will be developed. Therefore, to generate current in the rotor conductors and thereby produce torque, the rotor must run slower than the magnetic field. With commercial designs of squirrel-cage induction motors driving full load, the rotor operates at a speed of about 3 to 20% slower than the magnetic field, depending upon design of the individual motor.

The difference between magnetic-field speed and rotor full-load speed is called the *slip* of the motor. At no load, the rotor runs at practically the same speed as the magnetic field. As the load increases the rotor slows down to a point where enough current is generated in its conductors to produce load torque, unless the load is made too

great in which case the motor will stall. Torque developed when the motor stalls is known as the *pull-out torque*, which will vary from 150 to 250% of full load, depending upon motor design and its speed.

When the rotor runs slower than the magnetic field, current in its conductors has a demagnetizing effect on the stator. Now, if power is applied to the rotor and it is driven faster than the magnetic field, its conductors will cut the lines of force in a reverse direction and the voltage and current in them will be reversed. The current in the rotor conductors will now have a magnetizing effect on the stator and will increase the voltage induced in its winding.

Induction Generators

When the rotor runs 1 or 2% faster than the magnetic field, voltage induced in the stator winding is equal to line volts and current is not taken from the line. Increasing the speed causes the stator winding to act as a generator to deliver power to the line. Sometimes induction motors are operated as generators and are then known as *induction generators*.

When an elevator driven by an induction motor lowers a heavy load, the rotor runs at a speed slightly above synchronous. This causes the stator winding to supply power to the line and the motor then acts as a brake to keep the car and load under control just as a dc motor does.

Stator frames of general-purpose squirrel-cage motors are built in three general forms: *core*, *skeleton* and *riveted*. Fig. 1 shows a core-frame or box-frame stator. Of cast iron, the frame is ribbed on the inside to add strength and provide free air circulation around the windings and core. Fig. 10 shows a skeleton-frame stator, all superfluous metal having been cut away to leave only ribs and end rings of the frame for supporting the core. In the riveted-frame construction, Fig. 11, the stator core is held under heavy pressure between two cast-steel end rings so that the core forms part of the frame.

In the stator core two types of slots are used: *open*, Fig. 12*A* and *semi-closed*, Fig. 12*B*. Semi-closed slots provide a better distribution of magnetic flux in the air gap, as shown. This results in a slightly higher power factor, efficiency, starting torque, and overload capacity. Semi-closed slots, however, are generally limited to small machines, due to winding-design considerations. In large-size machines, semi-closed slots are not as vital a factor in efficient operation as in smaller machines.

Rotor windings provide the greatest differences in construction. In earlier designs, the bars were insulated with fibre in the slots and their end rings were connected by some form of bolted and soldered connection, Fig. 16. Heating and vibration in operation frequently caused the windings to work loose in the slots. This produced noisy operation and also increased the tendency for the connections to work loose between the bars and end rings, and in some cases permitted the windings to work endwise in the slots.

Because of the low voltage generated in the windings, destruction of the slot insulation did not materially affect motor operation. Now, most modern squirrel-cage motors have rotor bars driven into the slots without insulation, and the end rings are brazed or welded to them. On some designs, the complete squirrel-cage bars and end rings are cast as one piece, on the core.

Other designs use a 1-piece winding, punched and formed from a thick sheet of copper, as in Fig. 15. The bars are formed by dividing the center section of the sheet into strips and turning these at nearly right angles to the plane of the sheet. The edges of the sheet are folded over to form the end rings. After the sheet has been formed it is machine-wrapped around the core, the bars being expanded into the slots by swaging. In each ring the single joint is welded.

Double Squirrel Cage

To have good starting torque and high efficiency with a squirrel-cage motor, the rotor winding must have a high resistance during starting and a low resistance when running. Meeting these requirements led to developing the double-squirrel-cage rotor winding. Fig. 14 shows a section of such a winding of simple design with a high-resistance winding in the top part of the slots and a low resistance winding in the bottom. At starting, high inductance of the bottom winding causes most of the rotor current to flow in the top winding to give a high starting torque. At operating speed, the inductance in both windings is low and the current flows in them practically inversely to their resistance and we have a low resistance winding for running with low losses and high efficiency.

Fig. 13 shows a section of the most recent design of a double-squirrel-cage winding. By an ingenious arrangement of slots in the rotor core, the bars in the top slots cross connect with the bars in the lower slots to give improved starting and running characteristics. This winding and fan vanes on the end rings are cast in one piece on the core.

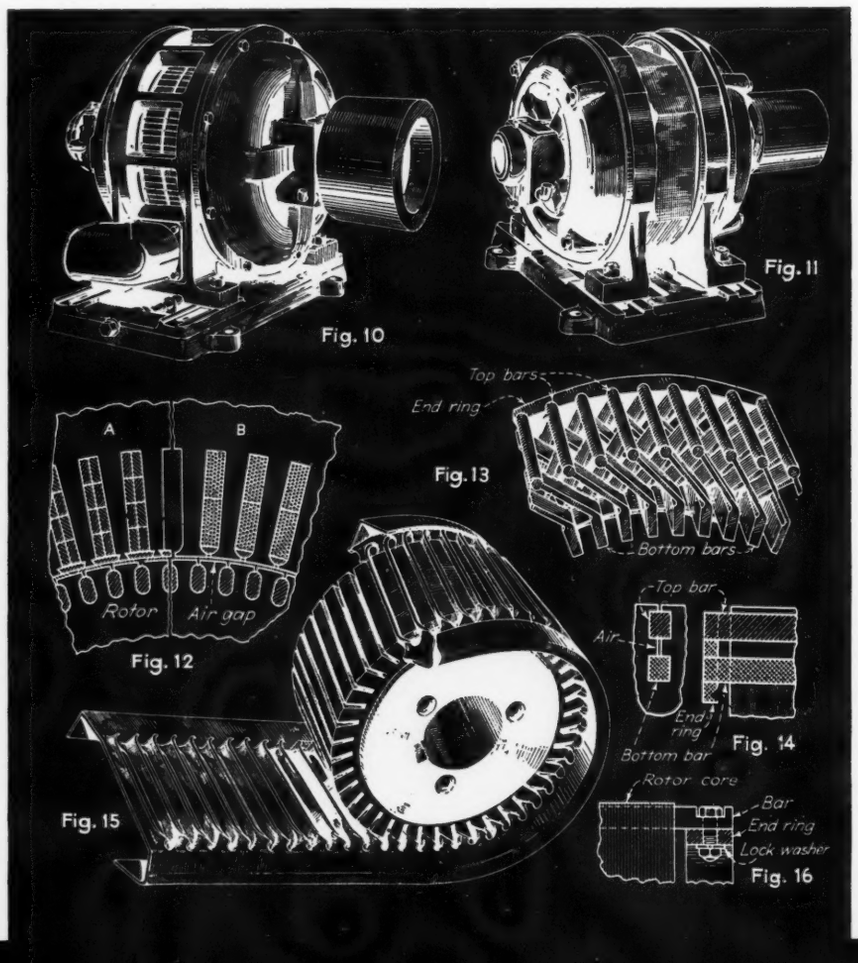


Fig. 10—Skeleton stator frame. Fig. 11—Riveted stator frame. Fig. 12—*A*, stator open slots; *B*, semiclosed slots. Fig. 13—Section of cast, interconnected double-squirrel-cage winding. Fig. 14—Section of simple double-squirrel-cage winding. Fig. 15—Squirrel-cage winding formed from a copper plate. Fig. 16—Joint between rotor bar and end ring

Starting Squirrel-Cage Motors

▶ SQUIRREL-CAGE INDUCTION MOTORS are started in several ways, depending upon motor design, size of power system, kind of load connected to the motor and other considerations. Present practice is to start these motors by connecting them directly to the power source where possible.

This method is the simplest, lowest in first cost, and requires a simple switch or contactor only (Fig. 1) as the starting device. Motors started on full voltage, however, should have their stator windings braced to withstand the magnetic forces produced on them by the high starting current.

Where conditions will not permit full-voltage starting, some form of reduced-voltage starter is used. One of these connects the motor windings in star (Fig. 1) for starting, and in delta (Fig. 2) for running. With the star connection, voltage across each phase is 58% of line volts. Since torque of an induction motor varies as the square of the voltage, then starting torque developed on the star connection is only about 33% of that obtained with the delta connection. This method of starting is therefore limited to loads requiring a low starting torque.

Resistors or reactors in series with the stator windings, Fig. 3, are also used to provide reduced voltage. At starting, the line contactor is closed, which puts the resistor or reactor in series with the motor windings. When the motor has accelerated, the running contactor closes and short circuits the resistor or reactor out of circuit. This method is low in first cost and the voltage at the motor terminals increases as its speed increases.

Resistor or reactor starting has the disadvantage of taking full-value starting current from the line. Auto-transformers overcome this objection by reducing the starting current taken from the line almost in proportion to the transformer ratio. If the starting voltage at the motor terminals is 70% of line volts, then the starting current taken from the line will be 70% of that supplied to the motor.

Fig. 4 shows the connections for starting a 3-phase squirrel-cage motor with two auto-transformers. (An auto-transformer is one in which the primary and secondary winding are combined into one.) Taps are brought out on the winding to give from about 65 to 85% line volts for starting. A tap should be selected on each transformer that will give the lowest starting voltage and current on which the motor can satisfactorily accelerate the load.

On the diagram, Fig. 4, arrows indicate current flow at one instant when the starting contacts are closed. After the motor has accelerated, starting contacts are opened and running contacts closed, which connects the motor directly to the line. Auto-transformer starters, or compensators as they are sometimes called, have the disadvantage or high first cost and the starting voltage remains practically constant at the motor terminals.

Where several squirrel-cage induction motors are started from one location, all may be started from one compensator. The compensator must have sufficient capacity to start the largest motor and can start only one motor at a time.

When an induction motor is first started it may run in the wrong direction. To reverse the direction of a 2- or 3-phase induction motor, it is necessary to reverse the direction of its revolving magnetic field. This can be done in a 2-phase motor by interchanging the connections to the terminals of either phase winding. On a 3-wire, 2-phase motor, the simplest way to reverse direction of rotation is to interchange the two outside leads. Fig. 5 shows a 2-phase motor connected to a 3-wire, 2-phase circuit for one direction of rotation and Fig. 6 shows the outside leads interchanged to the stator winding to change direction of rotation.

To reverse a 3-phase motor, interchange any two of the three leads on the motor terminals. The connections, Fig. 7, will give one direction of rotation and those in Fig. 8 opposite direction of rotation. This rule applies whether motor phase windings are connected star or delta.

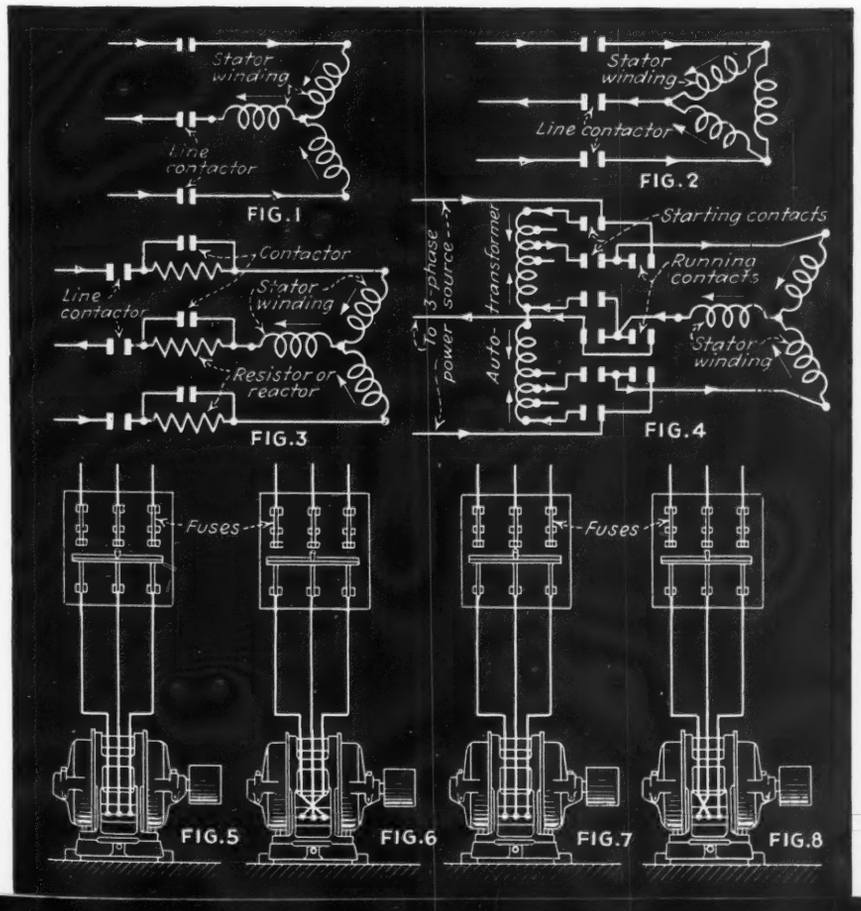


Fig. 1—Diagram of star-connected stator windings. Fig. 2—Stator windings connected delta. Fig. 3—Connections for starting with resistors or reactors in series with stator windings of a 3-phase motor. Fig. 4—Two auto-transformers connected to start a 3-phase motor. Fig. 5—Connections for one direction of rotation and Fig. 6, opposite direction of rotation of a 3-wire, 2-phase motor. Figs. 7 and 8—Connections for opposite directions of rotation of a 3-phase motor

Synchronous Motors

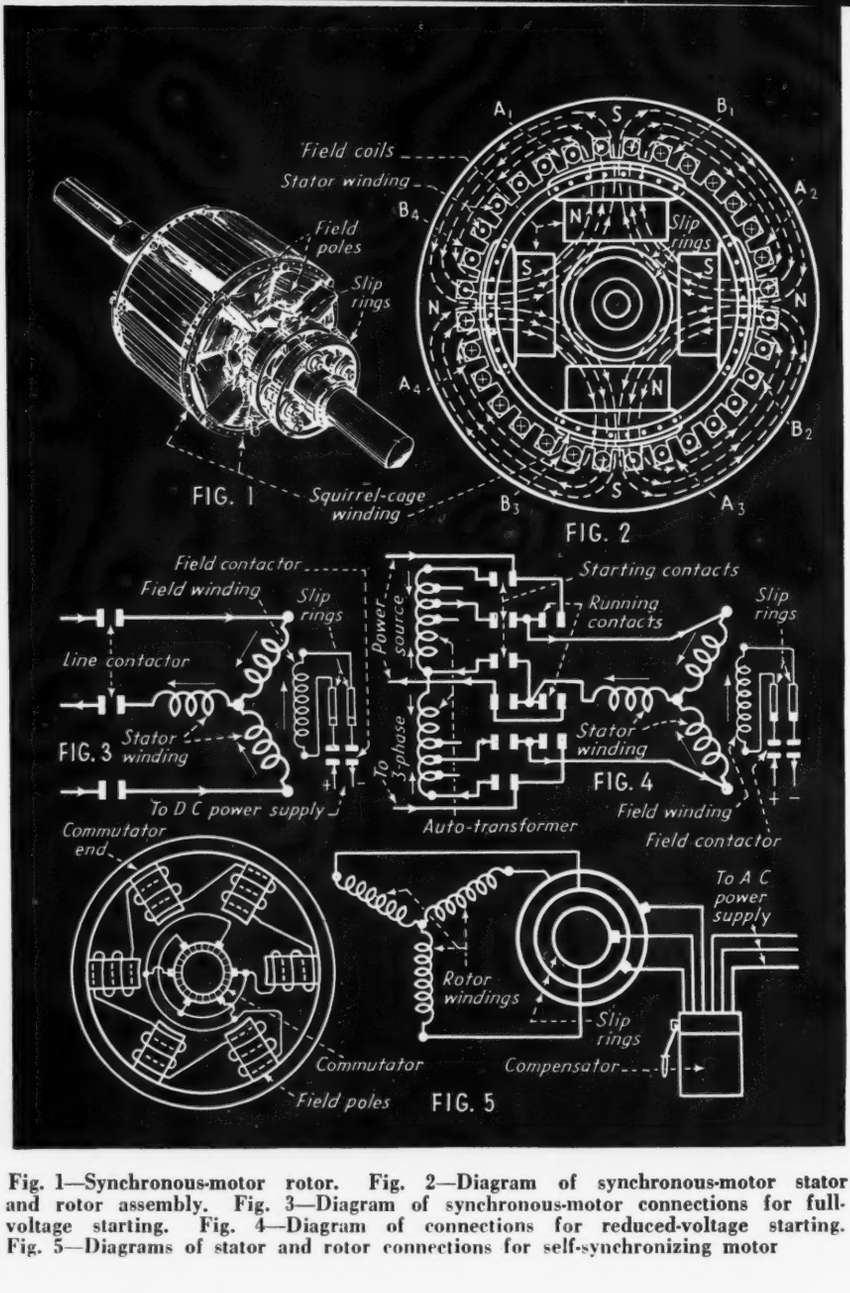


Fig. 1—Synchronous-motor rotor. Fig. 2—Diagram of synchronous-motor stator and rotor assembly. Fig. 3—Diagram of synchronous-motor connections for full-voltage starting. Fig. 4—Diagram of connections for reduced-voltage starting. Fig. 5—Diagrams of stator and rotor connections for self-synchronizing motor

▶ SYNCHRONOUS MOTORS are alternating-current generators specially designed to operate as motors. Their stator is similar to that of an induction motor, Fig. 1, page 76, but the rotor has field poles, like a direct-current motor, Fig. 1 on this page. These field poles are excited from a direct-current source—either a small generator driven by the motor or an outside supply. The rotor pole faces have a squirrel-cage winding for starting and that also helps stabilize the rotor after it pulls into synchronous speed. Excitation current is conducted into the field coils through brushes on the two slip rings, Fig. 1.

How They Operate

Fig. 2 shows the rotor and stator assembly of a synchronous motor. When the stator winding is connected to a polyphase alternating-current source, it produces a rotating magnetic field as in an induction motor. When the rotor field coils are connected to direct current, their *N* and *S* field poles lock into step with *S* and *N* poles of the rotating magnetic field and both rotate at the same speed or in synchronism. This speed is fixed by line frequency and number of rotor poles.

Synchronous motors are designed for two standard full-load power factors: unity and 80% leading. Unity-power-factor motors, at full load and normal field current, have 100% power factor. At less than full load, their power factor is less than unity leading, but can be regulated by adjusting the field current. This design of motor is used where starting conditions are normal and power-factor correction is not a major factor in selecting the motor.

The 80%-power-factor motor, at full load and normal field current, operates at a power factor of 80% leading. It has a higher starting torque, a higher pull-in torque and a higher pull-out torque than the unity-power-factor motor and is used where power-factor correction is a deciding factor in motor selection.

Early designs of synchronous motors had low starting torque, which limited their use. Modern motors are available that can start and pull their loads into synchronism under the most severe conditions, as the application chart, Fig. 6, shows. One design, known as a super-synchronous motor, can start and pull into step loads up to the limit of its pull-out torque. Two-speed synchronous motors are also available to operate at 100% and 50% speeds such as 600 and 300 rpm.

Slow-speed induction motors are not satisfactory because of their low power factor and efficiency. Synchronous motors, however, can be designed for any desired speed, and have high power factor and efficiency, for direct connection to compressors and other slow-speed applications. Motors of this type operate at speeds as low at 72 rpm.

Synchronous motors are started on full line voltage or on reduced voltage, depending upon their speed, the size of the power system on which they operate, and other factors. Slow-speed motors started on full-voltage do not take any greater current inrush at starting than do high-speed motors on reduced voltage. For this reason and because of the lower cost of full-voltage starting equipment, slow-speed motors are generally started on full voltage.

Fig. 3 shows a connection diagram for full-voltage starting. The line contactor is closed to start the motor and when it has accelerated to about 95% speed, the field-circuit contactor is closed and the rotor pulls into step with the rotating magnetic field. Reduced voltage for starting is commonly provided by auto-transformers, as in Fig. 4. Synchronous motors are also started by a part-winding method. The stator windings are grouped in two or more parts with their terminals brought outside the motor. One section of the windings is connected directly to the line for starting and the others paralleled with it as the rotor accelerates.

Whichever method of starting is used, the field circuit is not closed until the rotor reaches a speed where it can pull

into step when the field poles are excited. For most conditions this requires that the rotor be running at about 95% of full speed. With manual starting, the field switch is usually closed by hand, the time of closing depending on the operator's judgment. When starting automatically, relays of various types are used to close the field circuit at a time to give maximum pull-in torque.

Synchronous motors are generally not built in sizes smaller than 25 hp in slow-speed designs and 75 hp for high speed. In large-capacity motors there is practically no limit except the required power of the driven machine and a power system large enough to supply the motor. The Grand-Coulee pumps will be driven by 65,000-hp synchronous motors.

In sizes below those that can be economically met by synchronous motors, the Fynn-Weichsel induction-synchronous motor meets the demands for power-factor control. This motor is very much like a wound-rotor induction type, but has also an exciting winding on the rotor connected to a commutator. It is started as a wound-rotor motor and, when the rotor reaches about 95% full speed, pulls into synchronism and operates at synchronous speed.

These motors will develop a starting torque of 150% of full-load torque with 150 to 200% full-load starting current, at a power factor considerably better than a squirrel-cage motor of similar rating. With a corresponding increase in current, the starting torque can be increased to 250%.

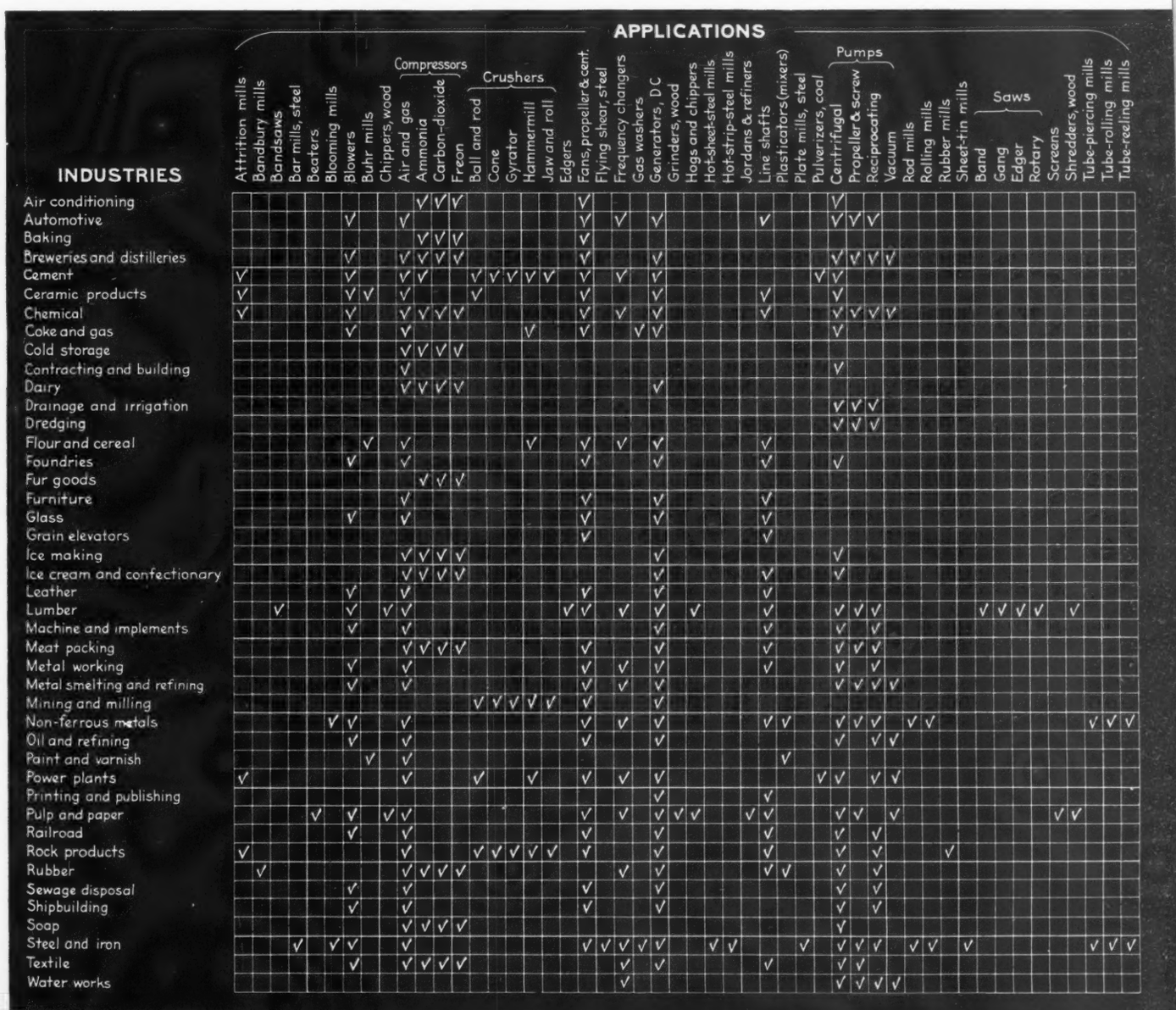
At synchronous speed this motor will carry 150% full load without falling out of step. Above maximum synchronous load, the motor falls out of step and operates as an induction motor up to its pull-out point when it stalls at about 250% full-load torque. If the motor is pulled out of step by a temporary overload, it will operate as an induction motor during the emergency and then pull into synchronism again when normal load returns. At full load, the power factor of this motor is unity and at light loads decidedly leading, similar to a unity-power-factor synchronous motor.

The self-synchronizing motor is another design built in small sizes. The stator of this motor is like the field frame of a direct-current motor but with a squirrel-cage winding in its pole faces. A light winding in the bottom of the rotor slots connects to a commutator. A heavy ac power winding in the top part of the slots connects to slip rings. The commutator connects to the stator field coils on the left, Fig. 5, and the slip rings connect to the power source through a compensator on the right, Fig. 5.

At starting, the compensator is closed to the auto-transformers and, as the motor accelerates, the compensator handle is shifted to run position as field excitation builds up and the motor pulls into synchronism automatically without attention from the operator.

This motor will also pull out of step and operate as an induction motor in emergencies and pull back into synchronism when normal conditions return. It is built in sizes of from 5 to 100 hp and for either unity or 80% power factor, full-load operation.

Fig. 6—Selection chart for synchronous motors



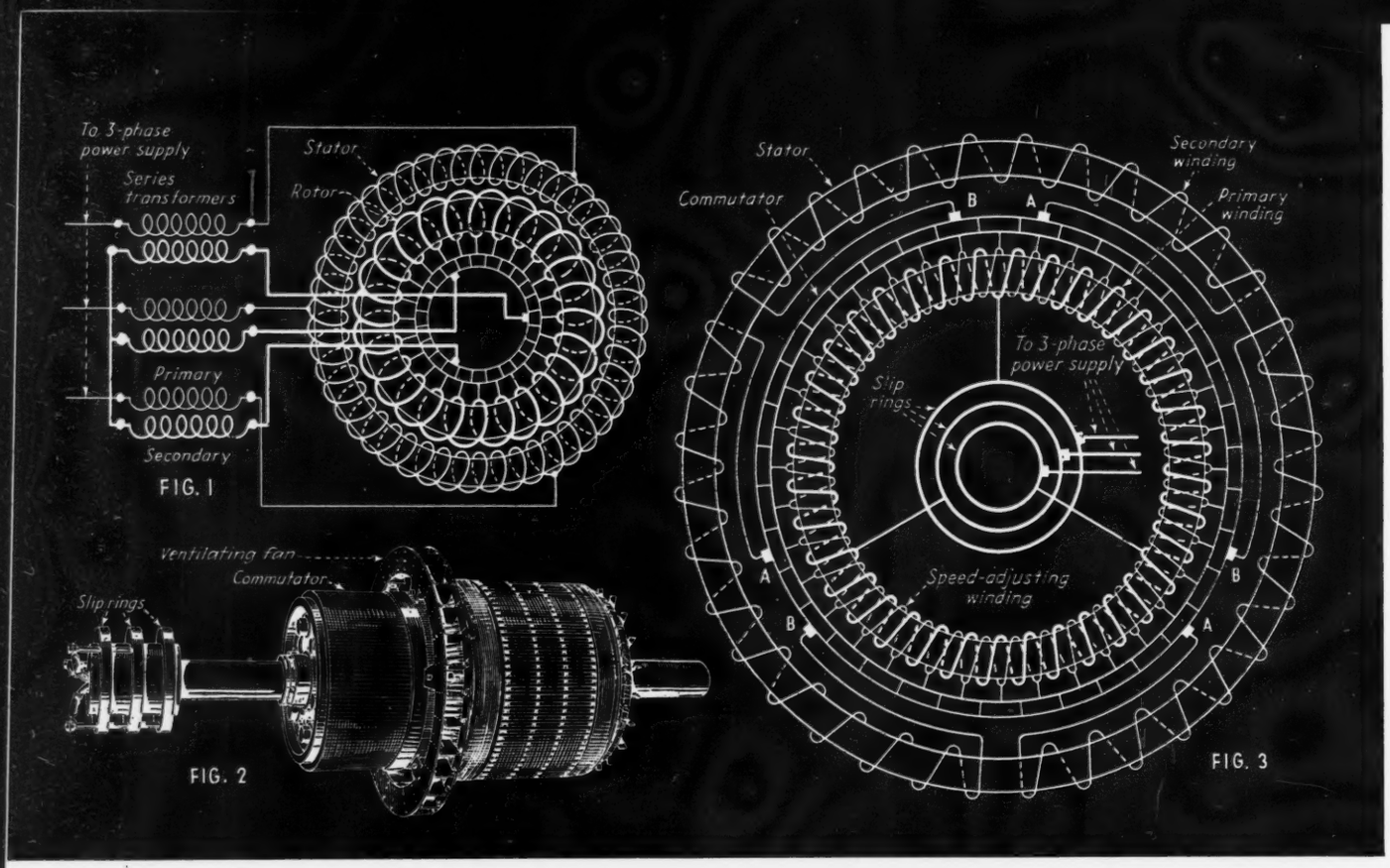


Fig. 1—Diagram of polyphase commutator motor, speed of which is varied by changing position of brushes. Fig. 2—Rotor for adjustable-speed polyphase motor. Fig. 3—Diagram of rotor and stator circuits for a polyphase adjustable-speed motor

Speed Adjustment

▶ SQUIRREL-CAGE MOTORS are the simplest and most rugged, but are inherently constant-speed machines. As explained on page 82, synchronous speed of these motors is fixed by the number of poles in their stator winding and the frequency of the power circuit to which they connect. Full-load speed is about 5 to 15% less than synchronous. These motors do not lend themselves even to being slowed down with resistance in series with the stator winding.

Many designs of variable- and adjustable - speed alternating - current motors have been developed, all more complicated than the simple squirrel-cage type. Some of them use a commutator or both a commutator and slip rings. The multi-speed squirrel-cage type is generally used when two or more fixed speeds will meet the application requirements.

This motor has a standard squirrel-cage rotor, but the stator winding is arranged so that it can be regrouped by suitable control for different number of poles. With a single stator winding, two speeds can be obtained, the lower speed being one-half of the higher, such as 1800 and 3600 rpm, 900 and 1800 rpm, or 600 and 1200 rpm. With two windings in the stator three or four speeds may be obtained.

Multi-speed motors are suitable where two to four fixed speeds will do the job. Many applications require adjusting the speed gradually over the operating range. For certain applications the requirements can be met with the wound-rotor motor, with external rotor resistance, described on page 84. Speed of this motor can be slowed down 50%, but if the load changes the speed will change inversely as the load.

Even though such motors may operate over a fairly wide speed range, they and their control are expensive and complicated, because the rotor winding must be regrouped in the same way as the stator winding for a change of speed.

Commutator-type motors are used extensively for many speed-adjustment applications. The adjustable, varying-speed, brush-shifting, series motor is in this class A brush-shifting, polyphase, series motor consists of a stator like that of an induction motor and a rotor similar to a dc armature. On the commutator are as many groups of brushes as the machine has pairs of poles times the number of phases. For example, on a 6-pole, 3-phase motor, there are $3 \times 3 = 9$ groups of brushes spaced around the commutator.

Stator and rotor windings are connected in series through series transformers, Fig. 1. In addition to supplying low-voltage current to the rotor, the transformers are designed to limit the no-load motor speed to a safe value of about 150% of maximum rated value at no load. Speed range of such motors depends upon several factors, but is approximately from 12.5% above to 50% below synchronous. Because these motors do not have large losses in external resistance, efficiency is much higher than that of wound-rotor motors in the same service.

Fig. 2 shows the rotor of a commutator-type polyphase motor designed for speed ranges of 3-to-1 and 4-to-1; for example, from 550 to 1650 rpm or 440 to 1760 rpm. When the speed of this motor is adjusted to a given value it remains practically constant irrespective of load change.

The rotor, Fig. 2, has two windings in the same slots. A primary winding in the bottom of the slots corresponds to the stator winding of a normal induction motor. Leads from this winding

are brought out through the center of the shaft to the three slip rings outside the bearing. Fig. 2. Brushes on these rings connected to the power source as in Fig. 3. A winding in the top of the rotor slots connects to a commutator as on a dc armature. On the commutator are two sets of brushes, each carried on its own yoke. The two yokes are geared together so that when one group is moved around the commutator in one direction the other group moves in the opposite direction for speed adjustment. Three groups of windings on the stator, corresponding to the rotor windings on a wound-rotor motor, connect to the two groups of brushes as in Fig. 3.

When the two sets of brushes are on the same commutator segments, the secondary winding is short-circuited similar to the rotor winding of a wound-rotor motor with all its internal resistance cut out. Under these conditions the speed-adjusting winding has no effect and the motor operates as an induction motor at a speed corresponding to the number of poles for which it is wound and the frequency of the power supply.

Imposed Voltage

When the brushes are separated on the commutator, as in Fig. 3, the section of adjusting winding between the brushes imposes a voltage on the secondary winding. If the instantaneous voltages in the secondary and adjusting windings oppose each other the current flowing in the secondary winding is reduced and consequently the torque developed by the motor. The rotor then slows down to where increased voltage of the secondary winding balances that developed between the brushes of the adjusting winding and restores the torque necessary to drive the load at reduced speed. The farther that brushes *A* and *B* are separated, the greater the opposing voltage impressed on the secondary winding and the more the rotor will slow down.

If we move brushes *A* and *B* by each other so that *A* is on the left and *B* on the right, adjusting-winding voltage will add to the secondary voltage to increase the current in this winding and the motor torque. As a result, rotor speed increases to where the secondary current is just sufficient to produce torque necessary to drive the load. The farther the brushes are separated the greater the speed increase. Thus, by simply shifting the brushes, speed of the motor may be increased above or decreased below synchronous value.

Fig. 4 is a diagram of a polyphase commutator-type adjustable-speed motor that uses an external speed regulator. This motor has a stator similar to a normal induction motor with its winding connected directly to the line. The rotor winding connects to a commutator as on a dc motor. Brushes on the commutator are on the neutral and connect to an induction-type voltage regulator, which provides the speed-adjusting voltage.

With its brushes short-circuited this motor operates like a wound-rotor induction type and will run at a speed slightly below synchronous. If, instead of short-circuiting the brushes, we adjust the regulator to apply a voltage to them equal and opposite to the rotor voltage, no current will flow and the motor will not start. Now, if we reduce the regulator voltage, a current flows in the rotor, it starts to rotate and will come up to a speed depending upon the amount the regulating voltage is reduced. When the regulating voltage is reduced to zero the rotor speed will be slightly below synchronous, just as when the brushes were short-circuited.

If we reverse the regulator voltage applied to the brushes it will add to the rotor voltage and the speed will increase above synchronous. The amount of speed increase will depend upon how much we raise the regulator voltage. Therefore, by the simple expedient of adjusting the voltage regulator, motor speed may be adjusted over a wide range. Speed range of the standard motor is 1720 to 580 rpm.

Several other systems of regulating the speed of ac motors have been used, some of which are economical only for large motors. Where the speed of all machines in a process require adjustment as a unit, a single ac generator may be installed to serve the group and its speed adjusted to give desired motor speed.

For a great many applications where adjustable speed is required, alternating current is converted into direct current to supply adjustable-speed dc motors. Where very wide ranges of speed and close speed regulation are required variable voltage is used. In such a system, each dc current motor is supplied with power from an individual dc generator driven by either a squirrel-cage induction or a synchronous motor. The armature of the dc motor is tied directly to that of the generator and speed is controlled by adjusting the voltage of the generator. This system has been developed using high-speed vertical motor-generator sets that make it suitable for even the smallest applications where wide range of speed adjustment is needed. For many speed-adjustment jobs, a simple squirrel-cage motor is used in combination with some form of variable-speed transmission, of which several designs are available.

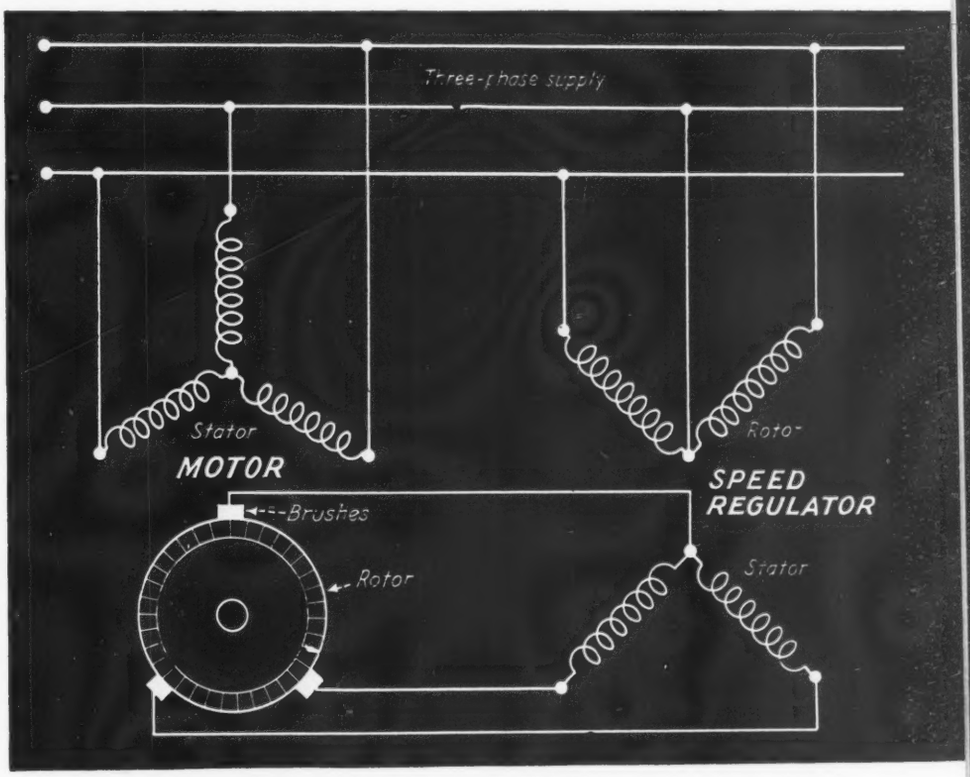


Fig. 4—Diagram of a polyphase commutator-type polyphase motor using an induction-type voltage regulator to adjust speed

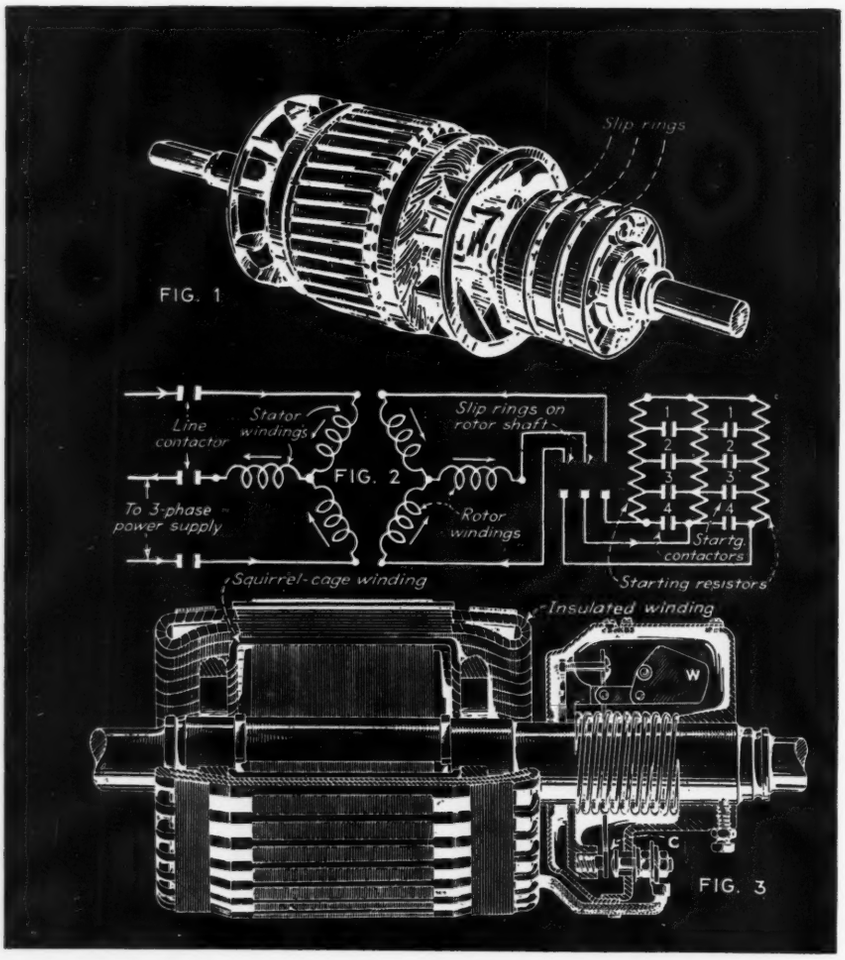


Fig. 1—Rotor for a wound-rotor or slip-ring motor. Fig. 2—Diagram of wound-rotor motor and its starting resistance. Fig. 3—Combination of a squirrel-cage and a coil winding on rotor, for automatic starting.

Wound-Rotor Motors

▶ HIGH EFFICIENCY with a squirrel-cage motor requires a low-resistance rotor winding. But such a motor takes a large starting current and develops a low starting torque. A rotor with a comparatively high-resistance winding develops a high starting torque, but the motor will have low efficiency and its speed will vary over quite a wide range from no load to full load.

Many designs have been worked out to combine high efficiency with high-starting torque, one of them being the wound-rotor or slip-ring type. This motor will develop about a 300% full-load starting torque on 300% full-load current and is used where high-starting torque is required and the starting current must be kept to a minimum.

It has a stator winding similar to that of a squirrel-cage motor, Fig. 1, page 76. The rotor, however, is wound with insulated coils, grouped in a 3-phase winding and connected to three slip rings as in Fig. 1 on this page. Brushes on these rings connect to an external resistance, Fig. 2, that is cut out as the rotor comes up to speed.

At starting, the line contactor is closed to energize the stator winding. Then, starting contactors *1*, *2*, *3* and *4* close in sequence to short circuit the resistors and regulate the starting current as the rotor accelerates. The resistors can also be used to slow the rotor down to about 50% of rated speed, but they must be designed for this service. At speeds below 50%, motor operation may be unstable if load fluctuates.

Several designs of wound-rotor motors have been developed to make the motor and starting resistor self-contained. In one of these, resistors inside the rotor are cut out of circuit manually, as the rotor accelerates. Another design uses resistors in the form of three piles of carbon disks placed radially inside a ring attached to the rotor. As the rotor accelerates, centrifugal force compresses the carbon piles and automatically cuts the resistance out of circuit.

The rotor for another design of self-starting motor is shown in Fig. 3. This rotor has two windings, a high-resistance squirrel cage in the bottom of the slots for starting, and a low-resistance insulated winding in the top half of the slots. The latter is grouped 3-phase, similar to the winding on the rotor of a wound-rotor motor. The three leads that would normally go to three slip rings connect, instead, to three contacts of an automatic switch mounted on the shaft. At about two-thirds synchronous speed, weights *W* swing out and close the three contacts *C*, thus short-circuiting the leads from the winding. This winding then operates like that on a wound-rotor motor, with all the rotor resistance cut out.

Full-Speed Operation

At starting, the squirrel-cage winding will develop 2.5 times full-load torque. When the motor reaches full speed both high- and low-resistance windings operate together, dividing the load between them in inverse proportion to their impedance. The motor then operates as a constant-speed wound-rotor type.

A modern development of a high-starting torque, wound-rotor motor has the primary winding on the rotor and connected to three slip rings as in Fig. 1. Brushes on these rings connect through a contactor to the power supply. The stator has a high-resistance squirrel-cage winding in the bottom of its slots with a three-phase insulated winding on top, three leads from which connect to a contactor. A timing relay controls the closing of this contactor.

At starting, the line contactor closes and supplies power to the rotor and the motor accelerates as a high-resistance squirrel-cage type. After a predetermined period, the timing relay functions and closes the contactor to short-circuit the leads of the insulated stator winding. The motor then operates as one with two secondary windings in parallel, at good efficiency and low slip. Motors of this design take about 50% of the starting current and develop about 150% of the starting torque of an ordinary general-purpose squirrel-cage induction motor.

Single-Phase Motors

▶A UNIT SUCH AS SHOWN in Figs. 1 and 2, page 76, with a single stator winding, represents the simplest form of single-phase motor. However, such a motor, connected to a single-phase power supply, will not start. If its rotor is brought up to speed, by outside power, the motor will continue to run in whichever direction it is started. Self-starting single-phase motors must have some form of starting device, or be of special design.

Shaded-Pole Type

The shaded-pole type is one of the simplest self-starting single-phase motors. It has a stator, Fig. 1, like the field frame of a dc motor, built of laminated steel. A slot cut across each pole face holds a closed-circuit coil, called a shading coil, Figs. 1 and 2. This is often only a rectangular copper stamping.

When current increases in the main coils, a current is induced in the shading coils that opposes the magnetic field building up in the part of the polepieces they surround. This produces the condition of Fig. 3. When the main-coil current decreases, that in the shading coils also decreases until the polepieces are uniformly magnetized. As the main-coil current and the polepiece magnetic flux continue to decrease, current in the shading coils reverses and tends to maintain the flux in part of the polepieces.

When the main-coil current drops to zero, current still flows in the shading coils to give the magnetic effect, Fig. 5. By comparing Figs. 3, 4 and 5, one can see that the magnetic field has moved across the polepieces from left to right, showing how the shading coils produce a rotating magnetic field that makes the motor self-starting. This type of motor suits applications where starting torque is low, such as small fans, and comes in fractional horsepower sizes only.

The split-phase motor with running and starting windings in the stator, represents another self-starting single-phase type. The winding produces conditions at starting resembling those in a 2-phase motor.

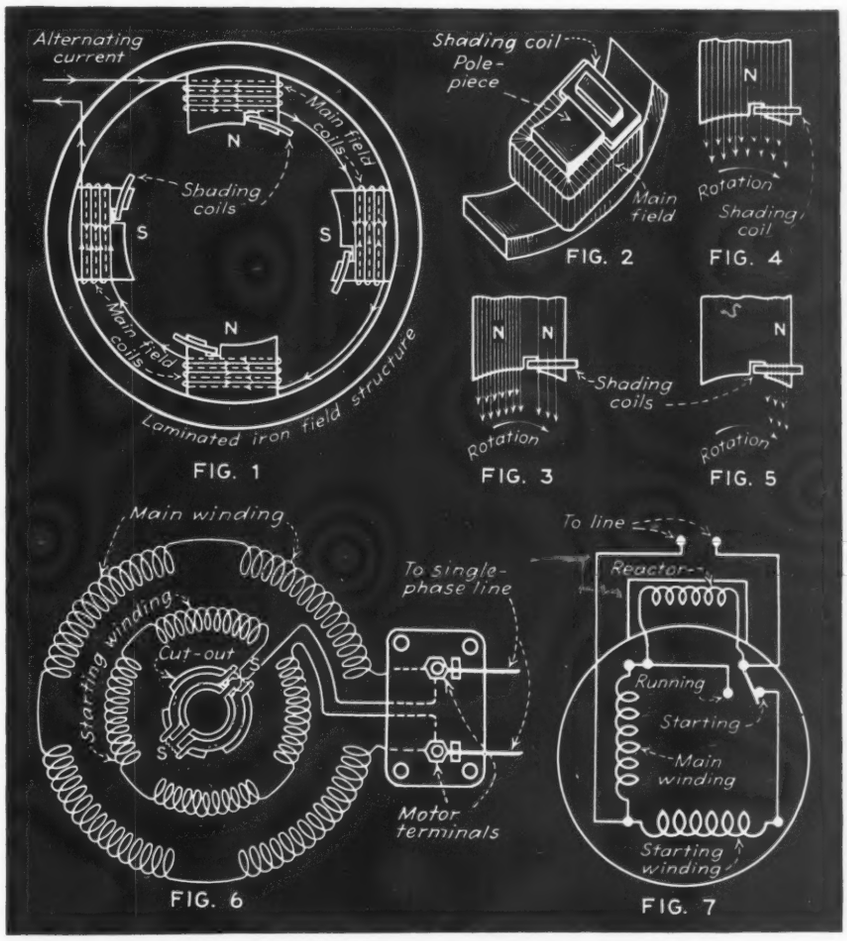
Fig. 6 shows one design of split-phase motor. The main coils have comparatively low resistance and occupy about 75% of the slot space. A high-resistance starting winding fills the remaining slot space, displaced from the main winding by 90 electrical degrees. The starting winding connects through the stationary parts of an automatic cutout switch, and is in parallel with the main winding, as shown. Cutout-switch movable parts are mounted on the rotor and held in contact with the stationary parts by springs *S*. At starting, both windings are in parallel. Differences in their impedance convert the single-phase line current into an equivalent 2-phase current that produces a rotating magnetic field, developing a torque to accelerate the rotor. At about 75% speed, centrifugal force opens the cutout switch and the motor comes up to speed on the main winding only.

Because a split-phase winding does not produce a true 2-phase relation between the currents in the two windings, starting torque is not as good as for a comparable 2-phase squirrel-cage induction motor, and the starting current is higher.

Split-phase motors are also built with an external reactor, Fig. 7, connected in series with the main winding at starting. At about 75% operating speed the starting switch throws from start to run position, opens the starting winding circuit and short circuits the reactor. Adding the external reactor reduces the starting current and increases the current lag in the main winding. This motor will develop about the same starting torque as that in Fig. 6, but with substantially less starting current.

Capacitor-Start Type

The capacitor-start, single-phase motor is a split-phase unit with a capacitor connected in series with its starting winding, Fig. 8. When the rotor accelerates to about 75% full speed, the cutout switch opens and disconnects the starting winding and capacitor. Starting torque varies with size and speed, being as high as 350% of full-



Figs. 1 to 5—How a shaded-pole, single-phase motor operates. Fig. 6—Diagram of split-phase motor. Fig. 7—Diagram of split-phase motor with external reactor

load value for small 60-cycle motors.

Single-value capacitor motors are also built so that the capacitor remains in circuit all the time. The diagram for such a motor is the same as Fig. 8, but without the cutout switch. These motors are built for special rather than general-purpose applications.

Fig. 9 shows a 2-value capacitor motor, which has a running and a starting capacitor. The starting switch connects the two capacitors in parallel. After acceleration, the starting switch opens and cuts out the starting capacitor. The motor continues to run with the running capacitor and auxiliary winding permanently in circuit.

Another design uses a single capacitor and an auto-transformer to obtain the effect of a 2-value capacitor. At starting, the auto-transformer impresses about 600 volts on the capacitor. After the motor starts, an automatic transfer switch changes taps on the transformer to reduce the capacitor volts to about one-half.

Two-value capacitor motors have higher efficiency, power factor and pull-out torque and operate more quietly than do capacitor-start motors. Developed for applications requiring high starting torque, they are now being replaced with capacitor-start motors. Several other arrangements of capacitor motors have been developed but those mentioned give a general idea of the types. To reverse the direction of either split-phase or capacitor motor, interchange the leads from the main winding on their terminals.

Commutator Types

A fourth group of single-phase motors includes commutator types. The simplest, a series motor to operate on alternating current, has typical series characteristics. In fractional horsepower sizes it fits a wide variety of small drives; larger sizes find use on railways and hoists.

Repulsion and repulsion-induction motors form another class of commutator-type single-phase motors. They fit general-purpose applications requiring constant speed and high starting torque with low starting current. The stator has a distributed winding like a squirrel-cage induction motor and a rotor like a direct-current-motor armature. The stator winding acts as a transformer primary to induce current into the rotor. Brushes on the commutator are connected together. Figs. 10 and 11 show the way these motors operate.

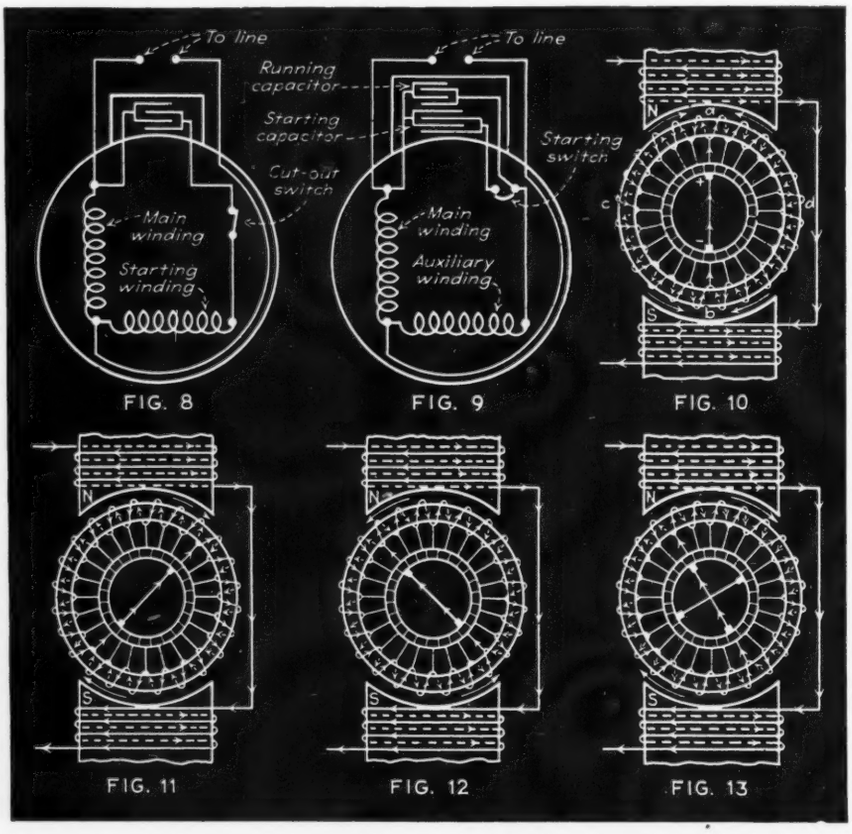
Fig. 10 shows a ring armature between two field poles with the field coils connected to a single-phase ac source. At any instant, assume current flows in the field coils as indicated by the arrow heads. As the field-pole magnetic flux threads through the armature coils it induces a voltage in them opposite to that applied to the field coils, as indicated by the arrow heads. This induced voltage varies from zero at *a* and *b*, under the center of the field poles, to a maximum at *c* and *d*, between them.

If brushes are placed as in the figure, maximum current flows in the armature coils. No effective torque is developed, however, because current in the coils under one-half of the pole faces in one direction, and that under the other half flows in the opposite direction. Shifting the brushes clockwise, as in Fig. 11, causes the current to flow in the armature coils as indicated. The current in the coils under the pole pieces now produces torque in clockwise direction, as shown by the curved arrows, which is the direction in which the brushes were shifted. To reverse rotation, shift the brushes to the opposite side of the field-pole center, Fig. 12. Normal brush running position is 15 or 20 electrical degrees either side of the magnetic-field center.

This design is known as a repulsion motor. Speed varies inversely as the load, and the unit will race if the load is removed. Placing a second set of brushes 90 electrical degrees from the first set, Fig. 13, will maintain constant speed. Motors of this type are also designed for 3-to-1 speed control by shifting the brushes around the commutator.

On what are known as repulsion-start and induction-run motors, a centrifugal device short circuits the commutator after the rotor reaches about 75% rated speed. On some designs of repulsion-induction motors the brushes lift off the commutator when it is short-circuited and on others the brushes stay in position. Repulsion and repulsion-induction motors can develop 450% of full-load torque on 325% full-load current. Using a resistor to control the starting current, full-load torque can be developed at 125% full-load current.

These motors are suitable for loads requiring high starting torque, where the starting current must be kept relatively low, such as on compressors, pumps, stokers, conveyors, etc. They are built in sizes of ⅛ to 15 hp. but the only limit in size is that permitted on a single-phase system.



Figs. 8 and 9—Diagrams of capacitor-type, single-phase motors. Figs 10 to 13—Diagrams of repulsion-type, single-phase motors

Applications

▶ WHEN WE FIRST CONSIDER the many types of ac motors available to meet the requirements of numbers of phases, voltages, frequencies, torque, variable- and adjustable-speed and other characteristics, it may look like a hopeless task to pick the right motor for a given job. The problem, however, is not nearly as difficult as it seems.

First, single-phase motors above fractional-horsepower sizes are generally restricted to applications where single-phase power only is available. In motor ratings of 1 to 200 hp, about 80% of all applications can be met by simple polyphase squirrel-cage motors of the first two classes in Table III, next page. Even a large percentage of adjustable-speed applications use this type of motor also in combination with a mechanical or hydraulic variable-speed transmissions.

Wound-Rotor Motors

Where starting conditions are severe or where starting current must be kept to a minimum, a wound-rotor motor is generally the best answer to the problem. For applications having high-peak loads, with or without flywheels, such as punch presses, shears, bulldozers, hoists, etc, high-slip, high-torque, squirrel-cage motors are well suited. When power-factor correction enters the problem, in motor sizes of 50 hp and up, synchronous motors are generally the answer. For slow-speed, direct-connected machines, synchronous motors have no competitors. These motors have been built for speeds as low as 75 rpm and have good efficiency. Low-speed induction motors have low efficiency, low lagging power factor, poor starting and pull-out torques.

Alternating-current motors of 200-hp rating and less for different classes of service have been standardized to quite a high degree by the National Electrical Manufacturers Association (NEMA). These standards and Table III are useful guides to the motors available, their characteristics and what can be expected of them.

Table I gives standard horsepower and synchronous-speed ratings of open and semi-closed, continuous-duty, constant-speed, general-purpose induction motors. Full-load speed of these motors is about 5% less than those given in the table. Standard ratings of synchronous motors cover a range of 20 to 5000 hp and 60-cycle speeds of from 3600 rpm (2 poles) to 80 rpm (90 poles). Motors for 25-cycle operation cover the same range of ratings and speed from 1500 rpm (2 poles) to 75 rpm (40 poles).

General-purpose induction motors listed in Table I are designed to be connected to their loads by gears, chain, belt or direct coupling. In ratings of 25 to 200 hp, speeds of 3600 to 900 rpm at 60-cycles and 1500 and 750 rpm at 25 cycles, standard lines of polyphase induction motors are available for direct connection only, Table II.

Where direct connection is required at other than standard speeds, gearmotors will generally be the best answer to the problem. These combine a motor and gear into a single unit that with single reduction gears requires very little more space than a standard motor. Motors on these units generally operate at 1800 rpm with a gear ratio to give desired output speed. These units are generally directly coupled to their loads, but where a large reduction from motor speed is required, they have been connected by belt or chain. Before doing this, check with the motor manufacturer to make sure that the output-shaft bearing will stand the increased load imposed by the transmission equipment.

Standard voltages for ac motors are 110, 220, 440, 550, and 2200 volts at frequencies of 25 and 60 cycles. Open-type, general-purpose, 60 cycle, polyphase motors can be operated on 50 cycles at rated voltages without temperature rise exceeding 50 C. A variation in voltage not exceeding 10% or in frequency not exceeding 5% is generally permissible with any induction motor. Such variations are always accompanied by changes from normal performance. For example, an increase in

TABLE I—STANDARD HORSEPOWER AND SYNCHRONOUS-SPEED RATINGS OF CONTINUOUS-DUTY, GENERAL-PURPOSE INDUCTION MOTORS

Cycle	*60*	*60*	*60*	*60*	*60*	*60*	*60*	*25*	*25*	*25*
Hp	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*
½									750	
¾			1,200						750	
1		1,800	1,200					1,500	750	
1.5	3,600	1,800	1,200					1,500	750	
2	3,600	1,800	1,200	900				1,500	750	
3	3,600	1,800	1,200	900				1,500	750	
5	3,600	1,800	1,200	900				1,500	750	
7.5	3,600	1,800	1,200	900				1,500	750	
10	3,600	1,800	1,200	900		600		1,500	750	500
15	3,600	1,800	1,200	900		600		1,500	750	500
20	3,600	1,800	1,200	900		600		1,500	750	500
25		1,800	1,200	900		600		1,500	750	500
30		1,800	1,200	900		600		1,500	750	500
40		1,800	1,200	900		600		1,500	750	500
50			1,200	900		600			750	500
60			1,200	900		600			750	500
75			1,200	900		600			750	500
100				900		600	450		750	500
125				900	720	600	450		750	500
150					720	600	450		750	500
200					720	600	450			

TABLE II—HORSEPOWER AND SYNCHRONOUS-SPEED RATINGS OF GENERAL-PURPOSE INDUCTION MOTORS FOR DIRECT CONNECTION

Cycles	*60*	*60*	*60*	*60*	*25*	*25*
Hp	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*
25	3,600					
30	3,600					
40	3,600					
50	3,600	1,800			1,500	
60	3,600	1,800			1,500	
75	3,600	1,800			1,500	
100	3,600	1,800	1,200		1,500	
125	3,600	1,800	1,200		1,500	
150		1,800	1,200	900	1,500	
200		1,800	1,200	900	1,500	750

voltage or a decrease in frequency will cause a decrease in power factor and efficiency and an increase in torque. The opposite effects accompany a decrease in voltage or an increase in frequency. Speed varies directly with frequency, but voltage changes have only slight effects on speed.

Standard, general-purpose, open-type, induction and synchronous motors are designed to carry full rated loads continuously with a 40-C temperature rise. Such motors operating at normal voltage and frequency will drive continuously 1.15 times rated load, that is, a 10-hp motor may be loaded to 10x1.15 = 11.5 hp without exceeding a safe temperature.

Motors for designed services where the load is not continuous are generally given what is known as a short-time rating, such as, full-load continuously for one hour. For elevator and hoist services, motor-horsepower ratings are based on full-load periods as short as 15 min. Services in which these motors are used are intermittent; therefore, during the time that they are operating they can carry more load without overheating than if loaded continuously.

AC motors are not only standardized according to electrical characteristics but also for types of protective inclosure. They operate in all kinds of atmospheric conditions; dust, acid fumes and moisture may be present and must be kept in mind when selecting motors.

Where satisfactory for the service, general-purpose, open motors should be used. They have no restrictions on ventilation other than those necessary because of mechanical features. Consequently, they have the highest rating for a given frame size and the lowest cost per rated horsepower.

In some locations, protecting screens are required over the end-shield openings of general-purpose motors. Also where there is danger of water or other liquids dripping onto motors, splash-proof inclosures should be used. Where more protection is required than given by splash-proof inclosures, use a totally inclosed design.

For high temperatures and explosive gases, totally inclosed self-ventilated motors are sometimes used. Motors with explosion-proof inclosing frames are also used where explosive gases are present. Where it is necessary for motors to operate in the presence of acid fumes, windings having acid-resisting insulation can be obtained.

For many applications, simple general-purpose, open squirrel-cage motors of proper size for your load with either manual or an automatic starter are all that you need. Beyond this, selection of motors leads into many ramifications, but before going into these one should know what types are available for solving the problem.

TABLE III—CHARACTERISTICS AND APPLICATIONS OF POLYPHASE AC MOTORS

Polyphase Type	*Ratings Hp*	*Speed Regulation*	*Speed Control*	*Starting Torque*	*Pull-out Torque*	*Applications*
General-purpose squirrel cage	0.5 to 200 hp	Drops about 3% for large to 5% for small sizes	None, except multi-speed types, designed for 2 to 4 fixed speeds	200% of full-load for 2-pole to 105% for 16-pole designs	200% of full-load	Constant-speed service where starting torque is not excessive. Fans, blowers, rotary compressors, centrifugal pumps, wood-working machines, machine tools, line shafts
Full-voltage starting, normal stg torque, low stg current, squirrel-cage	0.5 to 200 hp	Drops about 3% for large to 5% for small sizes	None except multi-speed types, designed for 2 to 4 fixed speeds	200% for 2-pole to 105% for 16-pole designs	200% of full-load	Same as general purpose motors above
Full-voltage starting, high stg torque, low stg current, squirrel cage	3 to 150 hp	Drops about 3% for large to 6% for small sizes	None, except multi-speed types, designed for 2 to 4 fixed speeds	250% of full-load for high-speed to 200% for low-speed designs	200% of full-load	Constant-speed service where fairly high starting torque is required at infrequent intervals with starting current of about 400% full load. Reciprocating pumps and compressors, conveyors, crushers pulvizers, agitators, etc
Full-voltage starting, high-stg torque, high-slip, squirrel cage	0.5 to 150 hp	Drops about 7 to 12% from no load to full load	None, except multi-speed types, designed for 2 to 4 fixed speeds	300 to 315% of full load, depending upon speed and rotor resistance	300%. This motor will usually not stall until loaded to its maximum torque, which occurs at standstill	Constant-speed service and high starting torque if starting not too frequent, and for taking high-peak loads with or without flywheels. Punch presses, die stamping, shears, bulldozers, bailers, hoists, cranes, elevators, etc
Wound-rotor, external-resistance starting	0.5 to several thousand	With rotor rings short-circuited, drops about 3% for large to 5% for small sizes	Speed can be reduced to 50% of normal by rotor resistance. Speed varies inversely as the load	Up to 300% depending upon external resistance in rotor circuit and how distributed	200% when rotor slip rings are short circuited	Where high starting torque with low-starting current or where limited speed control is required. Fans, centrifugal and plunger pumps, compressors, conveyors, hoists, cranes, ball mills, gate hoists, etc
Synchronous	25 to several thousand	Constant	None, except special motors designed for 2 fixed speeds	40% for slow-speed to 160% for medium speed 80% pf designs. Special high-torque designs	Unity-pf motors 170%; 80% = pf motors 225%. Special designs up to 300%	For constant-speed service, direct connection to slow-speed machines and where power-factor correction is required. For application see table, page 81

Troubles and Remedies

▶ BECAUSE OF THE SEVERAL DESIGNS in which alternating-current motors are built, troubles cover a very wide range. Even the squirrel-cage polyphase motor, which has no moving contacts and an insulated winding in the stator only, may develop a wide variety of troubles. These include speed below or above normal, noisy operation, low torque or failure to start, hot bearings, hot windings, motor running in wrong direction.

Low speed may be caused by low frequency or voltage, poor connections between rotor bars and end rings, faults in the stator windings, worn bearings and overloads. Speed of an ac motor varies as the frequency, other conditions being equal. With modern power-generating equipment the frequency is held fairly constant, so that there is little trouble from this source any more.

Low voltage is far more likely to be the cause of low speed than low frequency. Voltage in the power plant may be held constant but that at the motors will depend upon the distance they are from the power source, how heavily the lines are loaded and other conditions.

Loose connections between the rotor bars and their end rings cause low speed, noisy operation and low starting torque. In some cases, torque has been reduced to the point where the motor could not start its load. To cure this trouble, remove the end rings, clean the joints and, after bolting the ring to the bars again, weld or braze the joints.

Other causes of noisy operation are rotor bars loose in the slots, mechanical unbalance of the rotor, worn bearings, unbalanced voltages at the motor terminals and unbalanced stator windings. When rotor bars were insulated in their slots, it was not uncommon for the insulation to char because of excessive temperatures and for the bars to become loose. Worn bearings let the rotor rub on the stator and on gear drives the rotor shaft may be caused to pound the bearings.

When the stator windings are grouped in two or more parellels per phase, as in Fig. 1, one of the circuits may open as at X, but the circuit is complete through the other parallel section. This has the same effect as a large unbalance of the voltage at the stator terminals. To locate the defective phase test the current in each phase with an ammeter. If the phase windings are star-connected as in the diagram, ammeter readings taken in the motor leads will indicate the unbalanced phase.

Delta-Connected Windings

When the windings are delta-connected, ammeter readings taken in the motor leads will indicate to which lead the defective phase connects. After this it will be necessary to open the delta connection at the lead giving the low current reading, as in Fig. 2. Then take current readings through each of the two phases by connecting the ammeter from A to C and A' to B. The phase giving the low-current reading, which in the figure would be phase A' will be the defective one.

A polyphase motor will run single-phase but will not start after being shut down. Single-phase operation may be caused by a blown fuse, a poor connection or an actual break in a phase wire inside or outside the motor. If a motor fails to start, but makes a humming or a growling noise, one phase is probably open.

Because a polyphase motor starts when connected to a compensator, this is no indication that the motor does not run single phase when connected to full voltage. Cases are on record where the starting contacts all closed to start the motor, but on the running side one contact was open to cause single-phase operation.

Single-Phase Operation

If a main fuse is open on a circuit supplying several motors, as in Fig. 3, it may be possible to stop and start one of the motors while the others are running single phase. The running motors act as phase converters to supply polyphase power to start the motor that was shut down. Therefore, care must be taken when testing for single-phase operation not to get wrong indications. If motors are loaded to more than about 75% rated load, they will heat excessively, run at reduced speed and be noisy in operation when operating single phase.

Hot bearings may be caused by in-

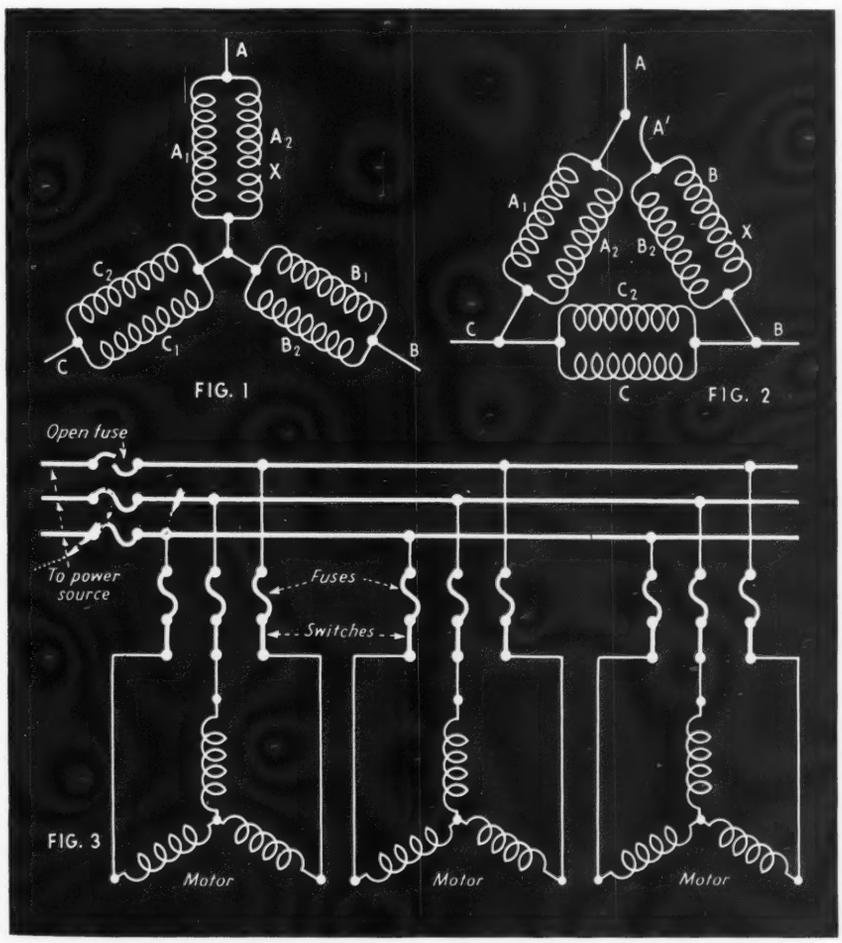


Fig. 1—Diagram of 2-parallel star-connected winding. Fig. 2—Two-parallel delta-connected winding. Fig. 3—Three motors connected in parallel on a 3-phase line

sufficient or improper lubrication; unequal air gap around the rotor, because of worn bearings, causes heavy unbalanced magnetic pull to overload bearings. Hot bearings may also result from oil ring not revolving with shaft, improperly fitted bearings, bearings out of line, bearing-cap bolts too tight or bent shaft, and end thrust due to machine being out of level or unbalanced magnetic pull. How to correct these faults is self-evident.

Overheating of windings may be caused by low voltage, unbalanced voltage, low frequency, overloads, poor connections in the rotor squirrel-cage, worn bearings letting the rotor rub on the stator, short circuits and grounds in the stator. Overloads may result from adding more machines, speeding up processes, misalignment of line shafting or machinery, and working the driven machine too hard under the control of an operator. Where there is danger of overload from the latter two causes, an indicating or a recording ammeter in the circuit to show the load on the motor is a good investment.

Short circuits or grounds in the windings will generally cause parts of the windings to be hotter than others. In extreme cases some of the coils may become sufficiently hot to cause smoking of the insulation. If a cold motor is connected to the line for a short time, the short-circuited coil can be detected by high temperature when touched with the hand.

When the short-circuited coil is located, it may be disconnected out of circuit as at *X*, Fig. 4, and the two adjoining coils connected as shown. To prevent the defective coil from heating it will have to be cut in two as indicated at X_1. Cutting out coils in the winding has the same effect as unbalanced voltage and should not be done except as a temporary expedient.

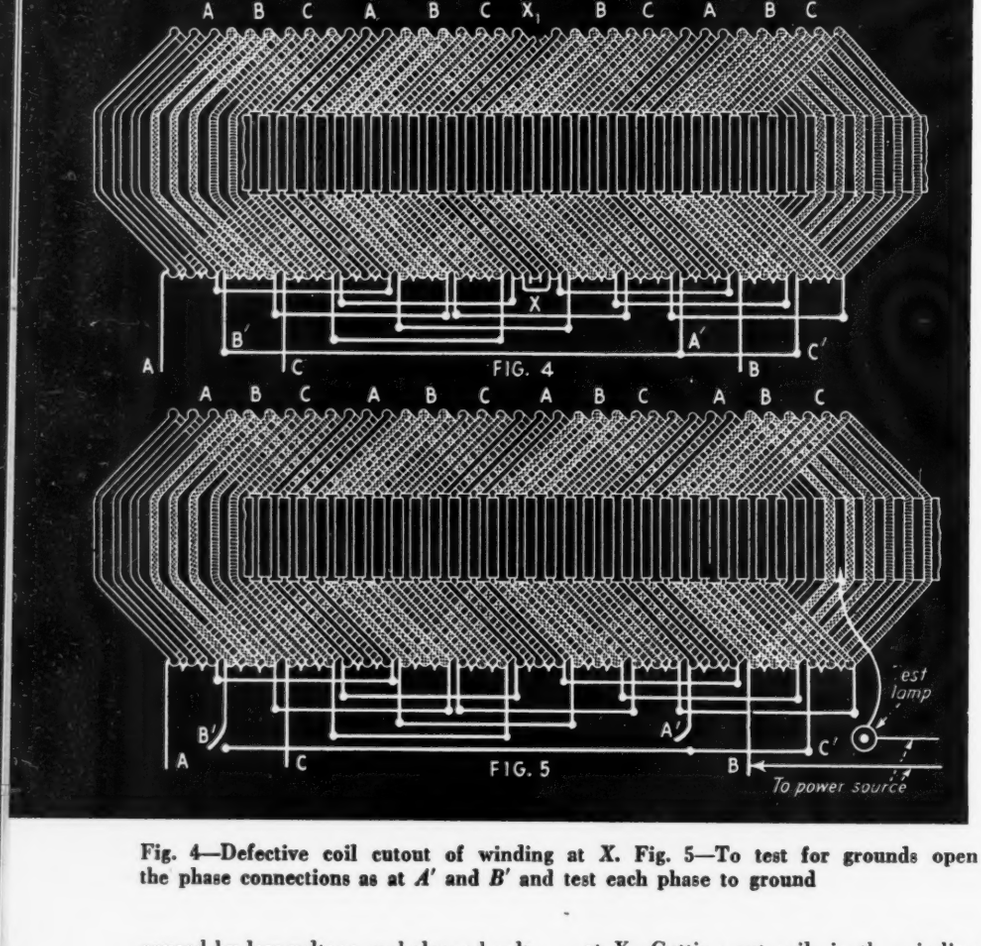


Fig. 4—Defective coil cutout of winding at *X*. Fig. 5—To test for grounds open the phase connections as at *A′* and *B′* and test each phase to ground

A ground in a winding when the power system is grounded will produce effects depending upon how the winding is connected and where the system is grounded. It will, however, cause heating of several coils and may blow one or more of the fuses. To determine if a ground exists in the windings, open the line switch and make the usual ground test with a lamp connected between the motor leads and frame.

Having found the motor circuit grounded, disconnect the leads at the motor terminals and test the motor winding and external wiring separately. If the fault is found to be in the winding, it frequently can be located by inspection. Failing in this, then open the phase connections of the windings, as in Fig. 5, and test each phase separately to ground. Having found the grounded phase, it may then be halved and tested for the grounded section, which in turn may be divided and again tested until the exact location of the ground is found. The defective coil may be jumpered out of circuit as explained for the short-circuited coil, Fig. 4. There are methods of testing directly for faults in ac-motor windings as in dc armatures, but those discussed assume that you are out on the job with nothing but a test lamp.

Wound-Rotor Troubles

Practically all the troubles mentioned for squirrel-cage motors can develop on wound-rotor motors plus several faults in the rotor because it has brushes, slip rings and an insulated winding. Grounds, short-circuits or open circuits in the rotor winding may cause noisy operation, low starting torque or excessive heating. Sparking at the brushes and slip rings may be caused by rings being out of round or worn rough, brushes sticking in their holders, overloads, brushes held to ring with insufficient pressure, poor shunt connections between brushes and holders, brushes not properly fitted to the rings, improper grade of brush used and other causes, most of which are evident by careful inspection.

Field Coils

Most of the faults outlined for squirrel-cage induction motors are applicable to synchronous machines. The synchronous motor also has field coils like a dc machine and slip rings. The discussion of field coil trouble on page 88 of the special section "Powered by DC," February POWER, is very largely applicable to the field coils of synchronous motors.

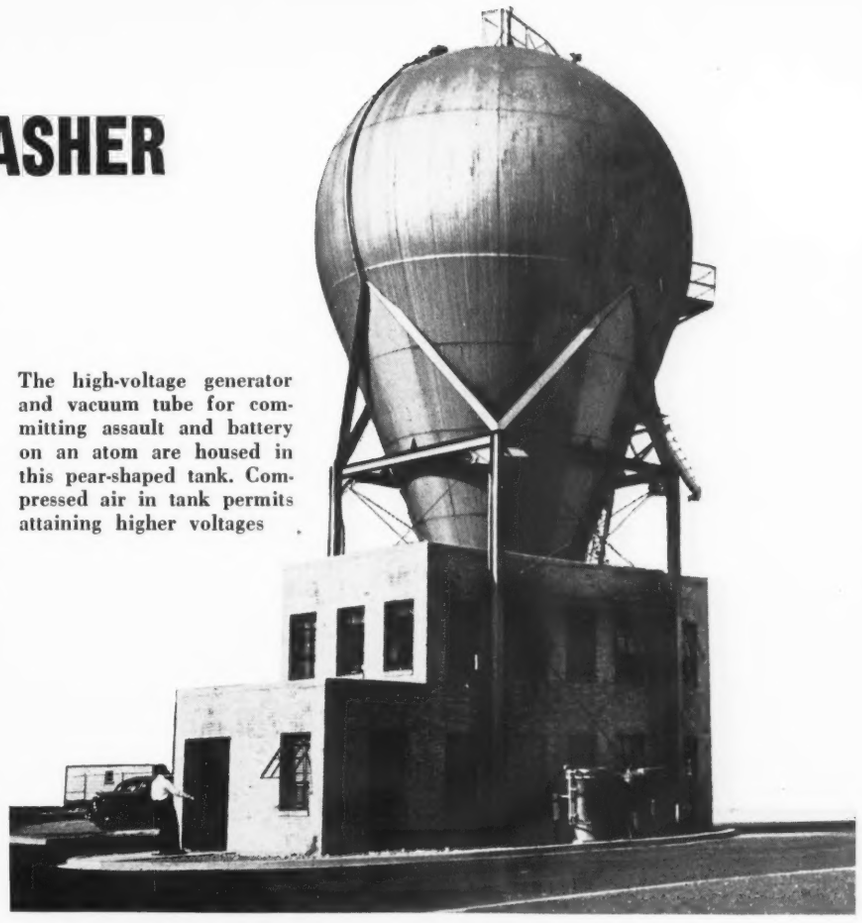
What has been said in the preceding paragraph about brushes on slip rings applies to those of synchronous motors. In addition, do not leave power on the field coils when the motor is shut down. The lack of proper ventilation will cause the coils to get very hot and the brushes are likely to burn spots on the rings. If both rings do not wear alike, occasionally reverse the flow of current to them.

The principles of good inspection and maintenance and the methods of making insulation tests given on pages 86 and 90, February POWER, also apply to alternating-current motors.

ATOM SMASHER

▶ ON THE TRAIL of today's most exciting science secret are the engineers and experimentalists operating atom smashers. Latest news in this field is the apparatus shown on this page, recently demonstrated publicly by Westinghouse Electric & Mfg Co, at its research laboratories in East Pittsburgh, Pa.

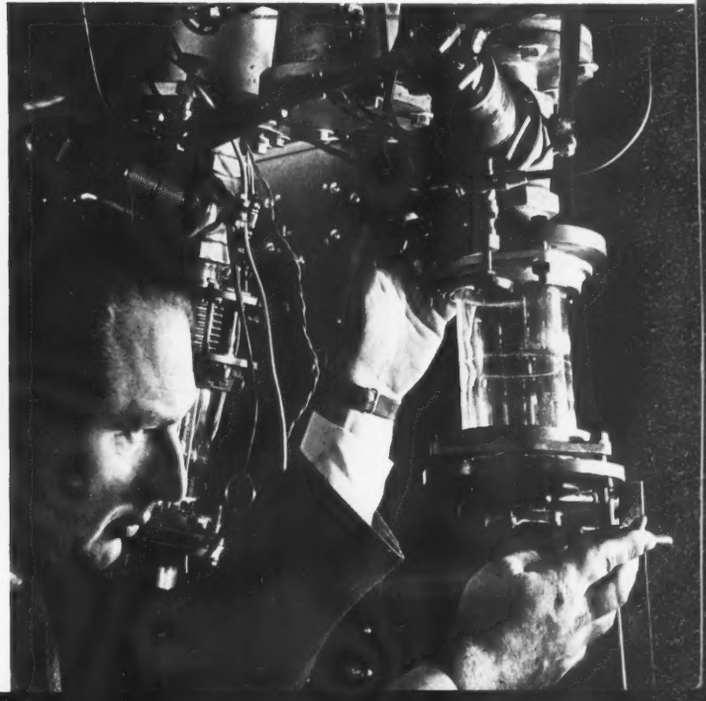
With the atom smasher, scientists are getting incredibly close to a complete understanding of the nature of matter. Fluorine has been changed to neon, graphite to nitrogen, table salt and sand have been converted into radioactive substances. More important than production of artificial radioactive materials is the fact that the voltage, up to 4,000,000 so far, can be held steadier than in any machine yet built, thus permitting precise measurements of the exact energy needed to produce these changes and hence of the force which holds the nucleus of an atom together.



The high-voltage generator and vacuum tube for committing assault and battery on an atom are housed in this pear-shaped tank. Compressed air in tank permits attaining higher voltages

This is what the inside of an atom smasher looks like. The belt at the left, driven by a motor outside the smasher, carries electric charges to the top of the 40-ft long vacuum tube where potentials as high as 4,000,000 volts are generated

At the bottom of the 40-ft tube of the atom smasher is the atom target holder. Inside this holder, targets a little larger than a penny are bombarded with subatomic particles



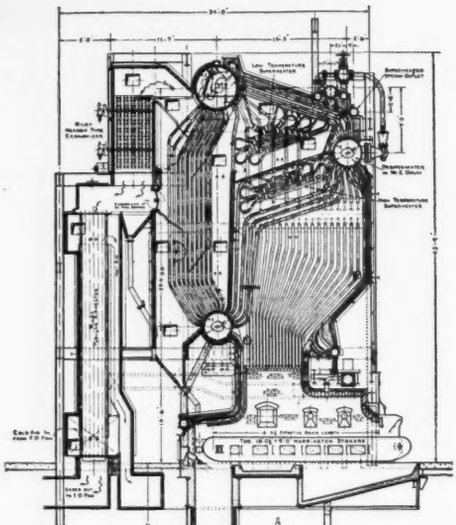
Mid-Western Coals . . Lignite . . the HARRINGTON STOKER

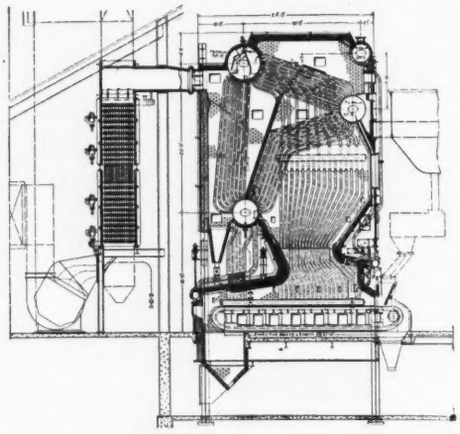
Here are a few examples of the excellent results being obtained from Harrington Stoker fired Riley Boiler installations burning fuels covering the entire range from anthracite to lignite. If you install Harrington Stokers you do not have to buy a special grade of coal in order to obtain satisfactory performance.

Harrington Stokers are satisfactorily meeting all load conditions and operating at high efficiencies with the cheapest, most easily obtained coals.

BURNING LIGNITE

This Harrington Stoker fired Riley Boiler Unit at the Wahpeton plant of the Otter Tail Power Company is the company's outstanding lignite burning installation. North Dakota lignite containing 40% moisture is burned at efficiencies over 82%, when producing 130,000 lbs. of steam per hour at 600 lbs. pressure and 825°F. steam temperature.





BURNING MID-WESTERN COALS

The Ohio Salt Company, Rittman, Ohio, recently installed the above Harrington Stoker fired Riley Boiler Unit. This unit when burning Ohio coal operates at an efficiency of 85.3% when generating 121,000 lbs. of steam per hour. The Ohio Salt Company was so well satisfied with the ease with which this unit was placed on the line and with the excellent operating results and construction and appearance of the unit, that they placed an order for a duplicate unit without competition, several months after the first unit went on the line.

TRADE MARK Rx REGISTERED

RILEY

STOKER CORPORATION, WORCESTER, MASS.

Boston New York Philadelphia Pittsburgh Buffalo Cleveland Detroit Tacoma Baltimore Milwaukee Denver
St. Louis Cincinnati Houston Chicago St. Paul Kansas City Los Angeles Atlanta Memphis New Orleans

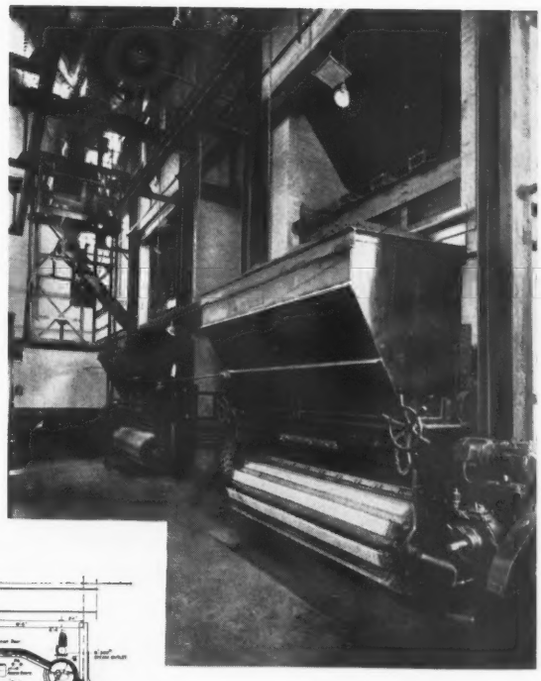
It will pay you to visit modern Riley Installations

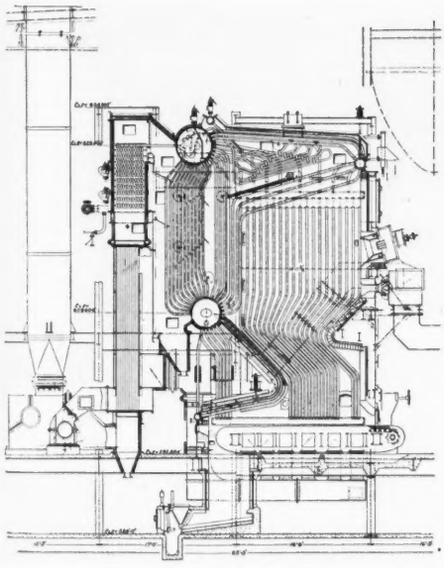
. . Anthracite . . Coke Breeze

burns them all efficiently

With the Harrington Stoker, you can use the cheapest fuels with the lowest freight rates, taking advantage of short haul coal.

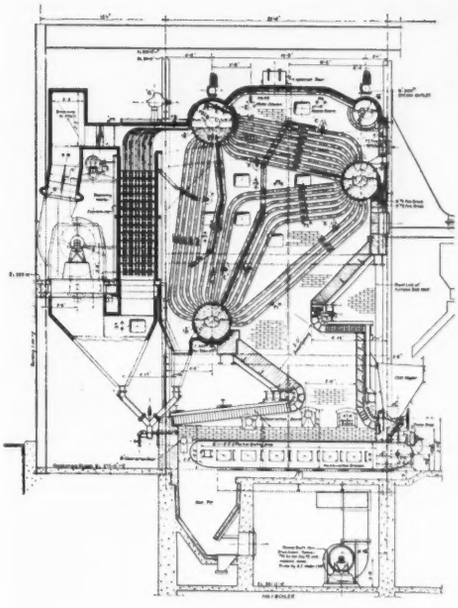
Because the Harrington Stoker can satisfactorily burn such a wide variety of coals, users of Harrington Stokers are not faced with the possibility of shut-downs in times of coal shortages or strikes. Many Harrington Stoker installations have shifted from anthracite to bituminous coals when the condition of the coal market dictated such a change.





BURNING COKE BREEZE

For the latest extension at the Great Lakes Steel Corporation's Hanna Furnace plant at Detroit, Mich., two Harrington Stoker fired Riley Units were selected to burn coke breeze. Blast furnace gas and coke oven gas are also burned at this installation. When burning coke breeze, the units operate at an efficiency of 84.3% at 75,000 pounds of steam per hour. A large number of the country's leading steel plants employ the Harrington Stoker for burning coke breeze. The Harrington Stoker is also used by many well-known gas companies for burning gas house coke breeze.



BURNING ANTHRACITE

At Imperial Paper and Color Corporation, Glens Falls, N. Y., the fine sizes of anthracite buckwheat are burned on Harrington Stokers. The complete Riley Boiler Unit operates at 78.5% efficiency at 50,000 lbs. of steam per hour. The Harrington Stoker also efficiently burns river coal. The ability of the Harrington Stoker to satisfactorily burn bituminous coals has enabled many installations primarily designed to burn anthracite to burn bituminous coals during times when anthracite coal was not available.

A survey of your power plant by a consulting engineer will possibly show ways of making surprisingly large savings in power costs

COMPLETE STEAM GENERATING UNITS

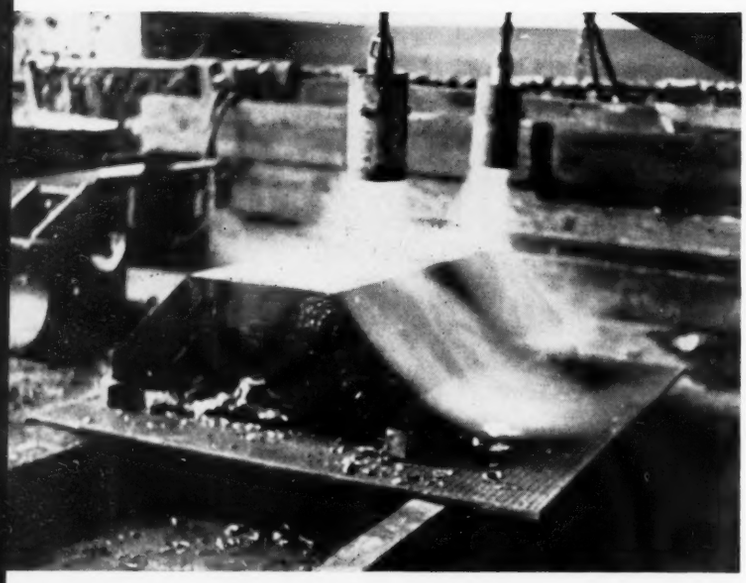
BOILERS • PULVERIZERS • BURNERS • STOKERS • SUPERHEATERS • AIR HEATERS
ECONOMIZERS • WATER-COOLED FURNACES • STEEL-CLAD INSULATED SETTINGS • FLUE GAS SCRUBBERS

before purchasing Boiler or Fuel Burning Equipment

Breaking Up Large Castings

▶ Gratifying results in reducing cost of dismantling plants have been reported by Carl R Wenz, Oklahoma Gas & Electric Co, Oklahoma City, Okla. By setting up internal stresses in castings by heating with natural gas and causing them to break at approximately predetermined points, both time and money can be saved.

Where flywheels are massive enough, the spokes may be heated until metal compresses. Then, when allowed to cool, the spokes will break loose from the flywheel rim



In salvaging babbit from bearings, salvage value can be increased by taking precautions to eliminate burning the babbit, by using natural gas to heat the bearing housing on the reverse side. This usually does not create temperatures high enough to change characteristics of the babbit

Acetylene and time can be saved by using an air lance with the acetylene torch in cutting large steel shafts. Actual time check shows a saving of 1½ hours in cutting a 26,000-lb. shaft

THE OPERATING ENGINEER

George Edwards
Advisory Editor

Practical Aids
Maintenance Hints
Questions — Answers

Published monthly as an integral part of POWER

This Small Plant Misses No Tricks

Lawrence Park Heat, Light & Power Co, a small and not-so-new plant, carries on in utility area by selling several power services and keeping costs down to bedrock

By LOU ROWLEY
Associate Editor

BACK IN 1904, power plants were few and far between in Westchester County, just north of New York City; one of them, housed in a little field-stone building on Kensington Road, was the Lawrence Park Heat, Light & Power Co, serving the new Gramatan Hotel and the Arcade Block in the growing suburban community of Bronxville. Today, in the heart of a territory efficiently supplied by one of the country's largest utility systems, this independent plant carries on, bigger and better than ever. How do they do it?

Here's the story as I got it on a recent visit: The original plant, equipped with a 100-kw and two 50-kw Ridgway engines and an 8x12-in. double-acting Voss ammonia compressor (all still on the job), supplied power, steam, hot water and refrigeration, and powered a deepwell pumping plant for water supply. As the holdings of the Lawrence Investing Co grew, load increased and in 1915 the plant began to supply heat to properties not held by the owning company. Today the area served covers more than a quarter of a square mile.

Only reminder of the old days in the boiler room is a battery of two 1500-sq-ft hrt boilers, fitted with hand stokers, now rated down to 60 lb and held for standby on heating loads. Four newer boilers (5000 sq ft, 4000, two 2500's) are E Keeler straight-tube box header units, rated for 160-lb operation, but run at 125 lb. Detroit underfeed stokers, 7 retorts and 4 retorts wide, respectively, fire the 5000-sq-ft and 2500-sq-ft boilers, while a Frederick 4-retort stoker handles the 4000-sq-ft unit. A 6x6-in. Sturtevant engine drives a common shaft for the 3 smaller stokers, with a motor at the other end for summer operation when there is no use for exhaust. A single motor drives the 7-retort stoker.

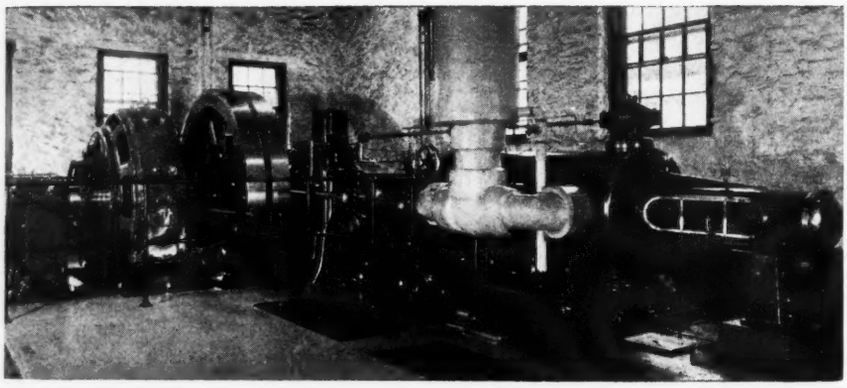
Coal, 1½-in. to slack, comes in on a rail siding and gets hand loaded in an industrial car. A hydraulic elevator lifts the car to a track running the length of the boiler house, with chutes feeding down to the stoker hoppers. Two men take care of all the handling, including weighing both coal and ash.

Steam-Driven Auxiliaries

Need for exhaust in winter makes it smart to drive auxiliaries by steam. A 75-hp Terry turbine drives the 75,000-cfm Green fan that handles most of the forced-draft; a 50-hp Westinghouse turbine powers a 40,000-cfm American Blower fan, used for peak loads and standby. Because an engine beats a small turbine on water rate, summer draft requirements are met by a 15,000-cfm Clarage fan, driven by a 7x7-in. American Blower engine. All fans feed into a common forced-draft duct, running under the boilers. A Carrick control regulates windbox dampers in accordance with changes in overfire pressure; fans run at constant speed.

Power partners for 25 years at Lawrence Park—W B Hambright, manager (seated) and L C Sands, chief

Being able to use exhaust profitably makes those old reliables—duplex feed pumps—look good at this plant. Three Worthington units handle the job, pumping through a single Sims closed heater in which exhaust steam raises feed temperature. With much of the heating system hooked up on vacuum returns, makeup only runs about 20% in winter months, jumping to 60% after the heating season is over. Makeup comes from the company's water system, part being raw water, 14 grains hard, and part being softened water. Present treatment, with a phosphate compound, does a fairly good job, but



300-kw uniflow takes bulk of load when exhaust isn't needed

Chief Sands would like to cut the cost. Boilers get opened up every three months, when tube ends are checked. Turbining once a year keeps tubes clean and there have been no tube failures. As long as operators keep boiler loads below 200% rating they don't get into trouble, but when loads get over 250% the headaches start.

The record of the 35-year-old Ridgway engines, still ready to grind out kilowatt-hours when needed, indicates kind of maintenance engine-room equipment gets; the pictures of these units and the newer 125-kw, Erie-Ball, 4-valve engine and the 300-kw, Ames uniflow give further proof of first-class care. Running at 7-lb backpressure, these prime movers drive 240-volt dc generators connected to a 3-wire, 120-240-volt system. Plans are afoot to swing lighting load and future power loads onto ac with frequency control. This will mean getting rid of the veteran 100-kw engine-generator and installing 150-kw and 200-kw engine-driven ac units.

Exhaust Supplies Heating

Exhaust from the engines, plus about 40,000 lb per hr of live steam on cold winter days, supplies the heating system covering about ¼ sq mile, with the longest run extending about half-mile to the Tuckahoe boundary line. In summer, hot-water heating takes about ½ of all available exhaust. Two motor-driven Nash pumps (rated at 90,000 sq ft of radiation, each) keep return lines under vacuum, with a 90,000-sq-ft Blake-Knowles steam pump for standby.

The new heating-system control, based on the first season's operation, is going to net a handsome saving. The arrangement works on the "timed-cycle" principle. Two Pendleton clocks control electrically operated valves in each of the 27 buildings, turning them on and off for longer or shorter periods as required by the weather. All the operator has to do is consult the outdoor thermometer, look at a chart, and set the clock—the rest is automatic. The system is so wired that any one of the buildings can be connected to either clock or can be thrown onto manual remote control.

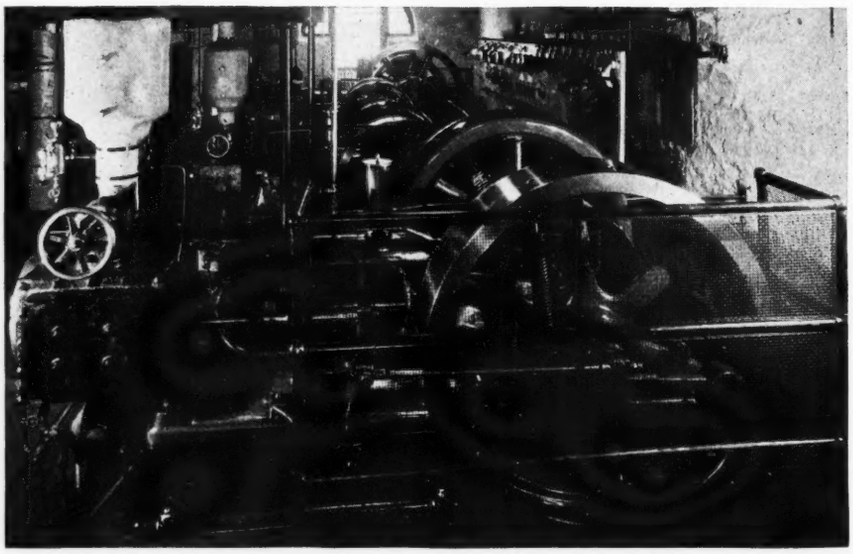
Manager Hambright puts a lot of faith in metering as a way to keeping down costs and shows it by installing condensation meters in buildings supplied with steam, flowmeters in the hospital, which buys live steam for sterilizers and the laundry, Bailey meters on each boiler for efficient operation, and a Simplex meter for measuring total boiler feed. The next step will be a meter to keep track of continuous blowdown quantities.

As Chief Sands puts it, coal is the "raw material" for his business, so he and Manager Hambright regularly test coals under actual working conditions to be sure they get the best their money will buy. They showed me a typical test sheet, comparing results of tests on 12 coals. For each coal, they list cost at mine, freight, total cost, % ash, % volatile, amount of coal tested, number of days run, lb of steam produced, evaporation rate, and average cost per 1000 lb of steam. A final column gives space for notes on behavior of the different coals on the grates.

Such a test setup usually points to several coals that give low cost and good operating characteristics, so final choice depends on spot market conditions. Both men admit that the method has weaknesses, but it is the best practical answer for a small plant, and if used with intelligence, far better than haphazard selection.

Getting the right coal keeps down stoker maintenance, and that keeps Chief Sands happy. Every 2–3 months boilers go down for inspection of stokers, deslagging, and cleaning back-connections. Engine maintenance follows no set schedule; Chief Sands indicates each unit once a year and uses the cards as guides for keeping the engines up to best performance. Keeping lube oil to a minimum helps prevent contamination of heating steam and returns and lightens the load on the Wright-Austin and Warren-Webster separators on the exhaust line and the Elliott terry-cloth grease extractor on the returns. No trouble has been experienced with oil in the boilers.

Working with a small crew (engineer, fireman, coal passer and 2 maintenance men on day shift; engineer, fireman and coal passer on afternoon shift; engineer and fireman on midnight shift) keeps cost down. A clean slate—25 years without a shutdown—proves that maintenance isn't skimped.



Old-timers still on the job: 100-kw and two 50-kw slide-valve engines in foreground date back to original installation of 1904. The 125-kw 4-valve engine at the far end, close to 25 years old, was installed in 1934

HOT-WATER BOILERS IN SERIES
Heat California Building

By THERON W BEAN
Mechanical Engineer,
Vallejo, Calif.

TWO HOT-WATER BOILERS of equal capacity, connected in series instead of the conventional parallel arrangement, heat a new California building with an hourly heat loss that hits a peak of 500,000 Btu in winter and drops to a low of 100,000 Btu in summer. For full automatic operation, controls on the integral oil burners are wired so that one boiler acts as base-load unit, with the other cutting in automatically when the load exceeds one boiler's capacity. Either can be used as base-load boiler by simply throwing a switch. The series hookup insures exactly equal flow through each boiler, which would be extremely difficult to accomplish with a parallel hookup.

Sufficient stop valves are installed to permit either boiler to be cut out for repairs when necessary. A glance at the piping diagram shows that closing gate valves 5 and 6, with 1, 2, 3 and 4 open, produces the normal hookup, with both boilers operating, and it can be seen how either could be operated alone. These particular boilers are vertical-fired units in which water flow in either direction is satisfactory, which accounts for up-flow in *A* and down-flow in *B*, in the diagram. The hookup could be modified easily to suit hot-water boilers in which maximum heat-transfer depends on direction of flow.

To follow the automatic-operation sequences, refer to both piping and control diagrams. The heating system is divided into zones in the usual manner, each zone having an individual indoor thermostat controlling operation of a motor-driven circulating pump. The main-return thermostat *R* is set to maintain 175 F in the return line. Each boiler has a submersion thermostat to maintain a minimum temperature of 180 F. An outdoor thermostat *O* closes only when outside temperature falls to 35 F, taking care of sudden changes.

How Setup Works

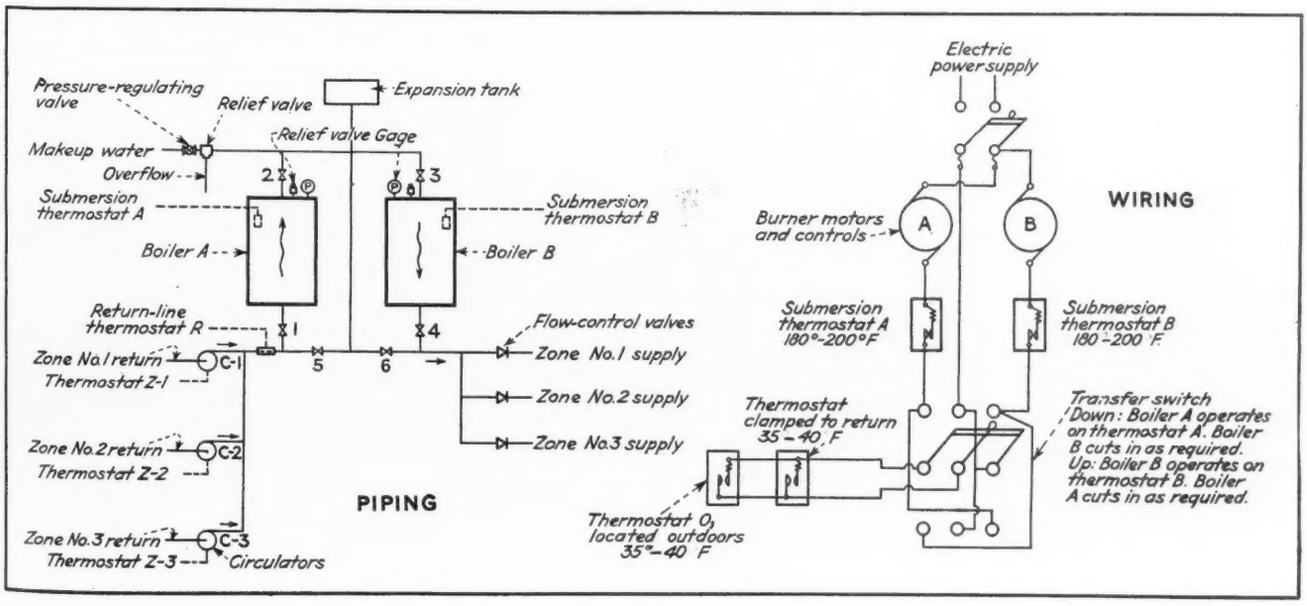
Assume that the transfer switch is in the down position. The burner of boiler *A* operates only in accordance with demands of the submersion thermostat *A*. The submersion thermostat in *B* can't take over, however, until either thermostat *R* or *O* closes, indicating that returns are cold, or that outdoor temperature has fallen markedly. Thus boiler *A* handles base loads, with *B* as standby ready to cut in when the load exceeds *A*'s capacity. By throwing the transfer switch to the up position, *B* becomes the base-load unit, and *A* the standby.

Although the system will function smoothly without the transfer switch, a standard, enclosed, triple-pole double-throw device, its use provides a simple means of alternating boilers so that one doesn't take the lion's share.

The outdoor thermostat is an anticipating device only, and should be set for a temperature that is low for the locality. If set too high it will short-circuit the return-line thermostat *R*, when the latter should be doing the controlling. If properly set, however, it makes an excellent safety device, throwing the standby boiler on its submersion thermostat with a minimum time lag when a severe cold spell comes on suddenly.

The thermostat settings given above would, of course, have to be varied to suit other installations. Initial adjustment of the submersion thermostats and the return-line thermostat requires a little experimenting to obtain the proper relation. Once adjusted, the system should operate without attention even through wide variations in outside temperature and total heat demand.

Piping and wiring diagrams show how boilers operate in series, serving alternately as base-load and standby units



OPERATING KINKS *from Rochester, N. Y.*

By PHIL SWAIN, *Editor*

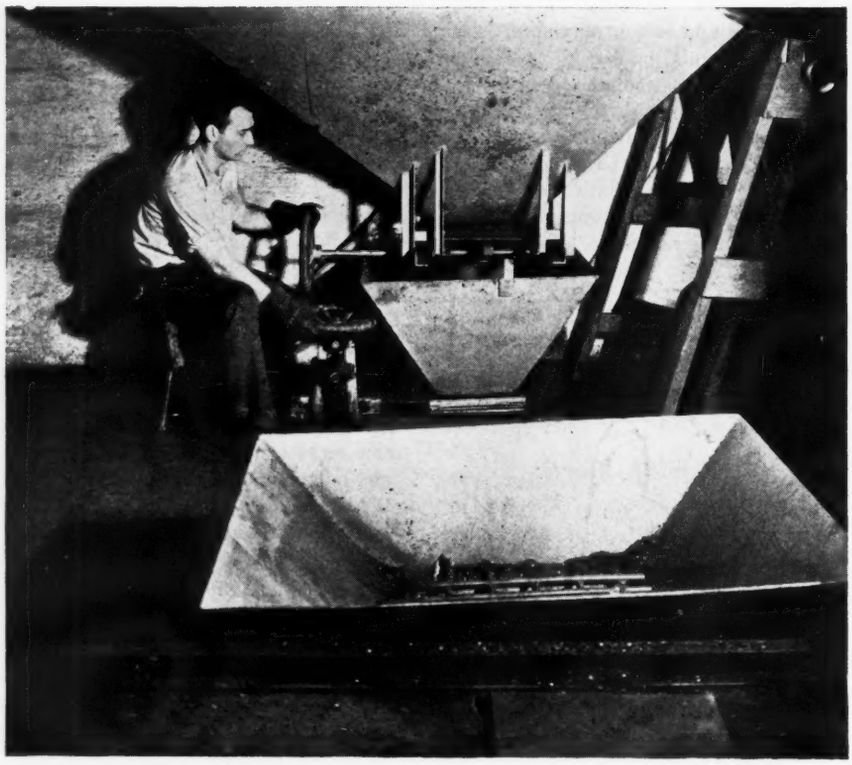


Fig. 1—Truck on roadway above dumps coal into large upper hopper. Operator uses lower (measuring) hopper to dish out standard doses to screw conveyor below. He tallies each filling on counter alongside

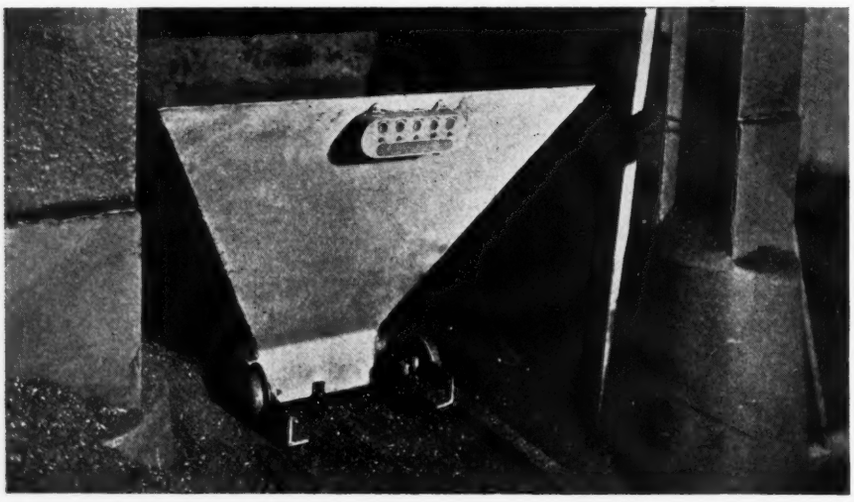


Fig. 2—Coal can be shoveled directly from storage to this calibrated hopper rolling over screw conveyor. Note counter for tally

A REGULAR EDITORIAL stop in Rochester, N. Y., is Bill Gessner's power plant at the Taylor Instrument Co. I always call on Bill, just in case he may have some new kinks, which he generally has. But even if he hadn't, the trip would be worthwhile anyhow to listen to one of the saltiest vocabularies to be found on dry land. For Bill went to sea to learn his engineering trade (I never heard him call it a "profession"). He is a chief who calls a spade a spade, has no use for stuffed shirts and believes engineering is 90% horse sense. He gives every man under him the chance to learn the whole power job, as evidenced by the fact that the fireman starts the turbine each morning.

Coal Conveyor

The principal addition since my last visit was a screw conveyor to save elbow grease in coal handling. Coal, dumped by truck into the underground storage pocket, was formerly toted in wheelbarrows to the bucket elevator serving the overhead bunkers that feed the pulverizing mills.

In the new labor-saving rig, the large upper hopper in the background of Fig. 1 will hold two truckloads of coal dumped from the roadway above. Generally truck deliveries are so timed that most of the coal gets into the system this way without rehandling with shovel.

The operator fills the lower (measuring) hopper direct from the upper, then dumps it to the screw conveyor below and tallies the count on a counter mounted right beside him. The coal is not weighed, but the measuring hopper is calibrated for capacity.

Of course there are times when the truck loads of coal come too fast. In that case they are dumped directly into the storage space (not shown, but behind camera, and to the left, in Fig. 1). Even here the wheelbarrow is eliminated, for the coal can be shoveled into the measuring hopper shown in Fig. 2. This rolls on a track running down the middle of the storage space and directly

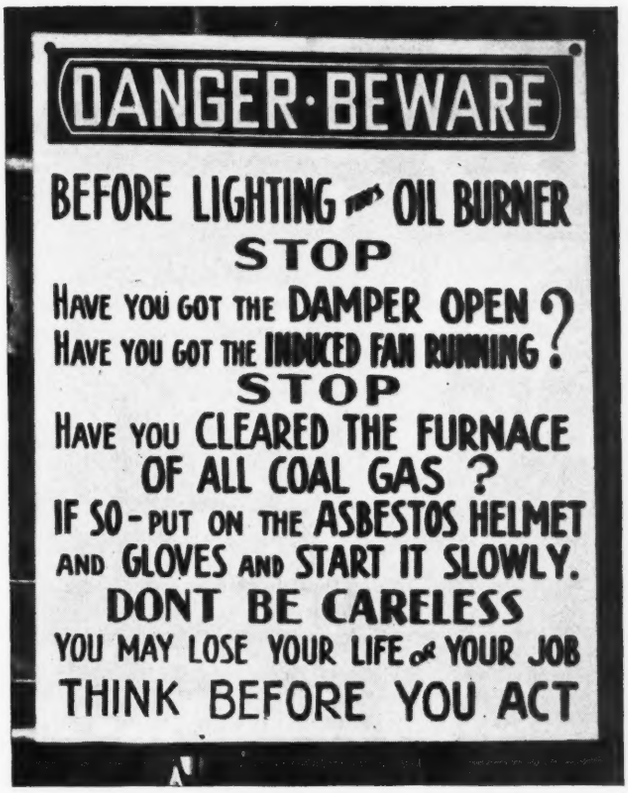

DANGER·BEWARE
BEFORE LIGHTING THE OIL BURNER
STOP
HAVE YOU GOT THE DAMPER OPEN ?
HAVE YOU GOT THE INDUCED FAN RUNNING ?
STOP
HAVE YOU CLEARED THE FURNACE
OF ALL COAL GAS ?
IF SO - PUT ON THE ASBESTOS HELMET
AND GLOVES AND START IT SLOWLY.
DONT BE CARELESS
YOU MAY LOSE YOUR LIFE OR YOUR JOB
THINK BEFORE YOU ACT

Fig. 3—Timely warning hangs over stairway leading to oil burners used for starting pulverized-coal fire

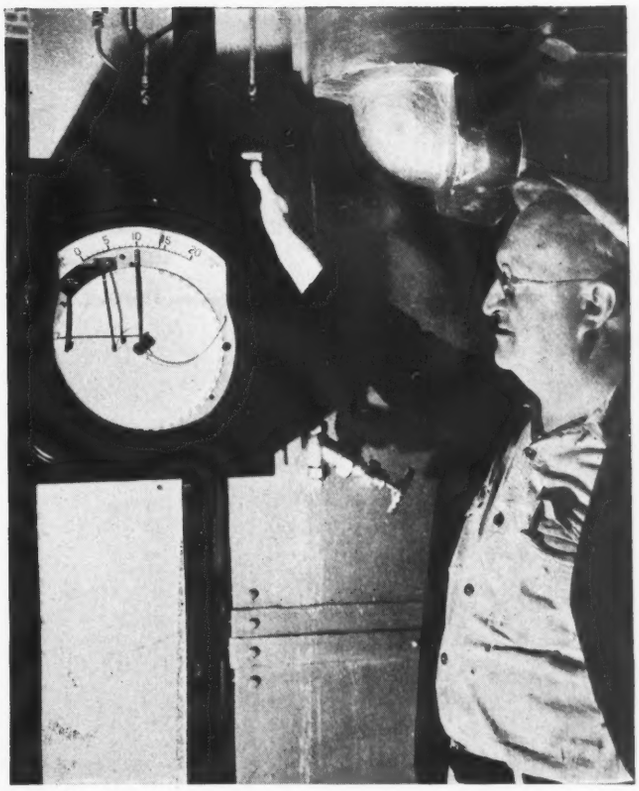


Fig. 4—Bill Gessner, sailor ashore and power-plant chief for Taylor Instrument, fondles his new CO_2 recorder

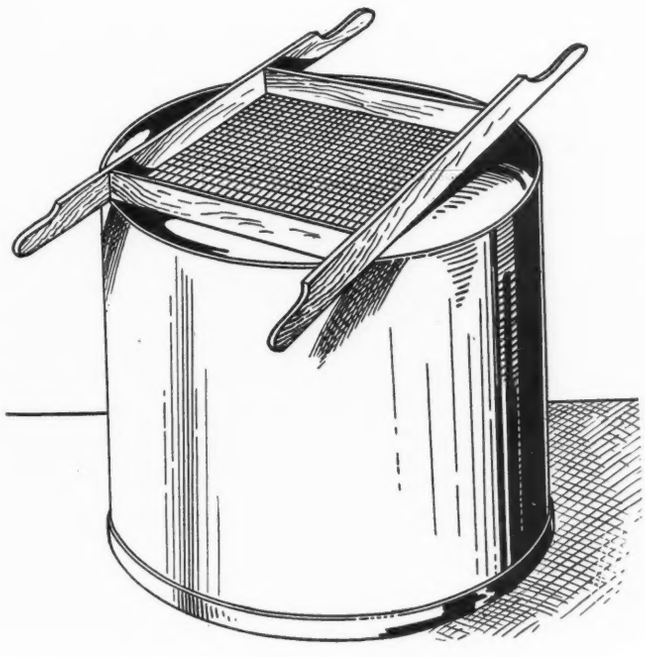
over the screw conveyor. It, also, is calibrated and equipped with a hand-operated counter. A similar hopper, stationary, appears in the foreground of Fig. 1. Gessner says this complete installation cost only $1200.

Kink No. 2 is the sign shown in Fig. 3. Lettered big in red and black, it hangs right over the stairway running up to the oil burners used to ignite the pulverized fuel when starting up the boiler. This sign is a warning placed where he who runs may read.

Kink No. 3 isn't a kink at all, merely a picture of two high-grade pieces of power equipment—one used, the other new—to wit, Bill Gessner and his recently installed CO_2 recorder. This (the recorder) is a distant-reading outfit with the dials out front and the analyzing elements close to the breeching, to avoid the lag and nuisance of long sampling lines.

Some engineers don't like CO_2 recorders. Bill does, says they are the most direct means of spotting and stopping major boiler-room waste—excess air.

✦ ✦ ✦



Screen Your Chemicals

WHEN MIXING DRY CHEMICALS into boiler feedwater-treating solution, keep large chunks out of the mixing tank. These dissolve very slowly, waste time, and require a lot of straining and possible crushing. Often they do not dissolve completely and result in an uneven solution which may upset boiler-water conditions.

You can avoid all these troubles by screening material, as shown in the sketch. Where necessary, break lumps to go through screen. Mesh should be strong enough to stand rubbing. If chemicals are harmful to the screen, wear protective gloves.

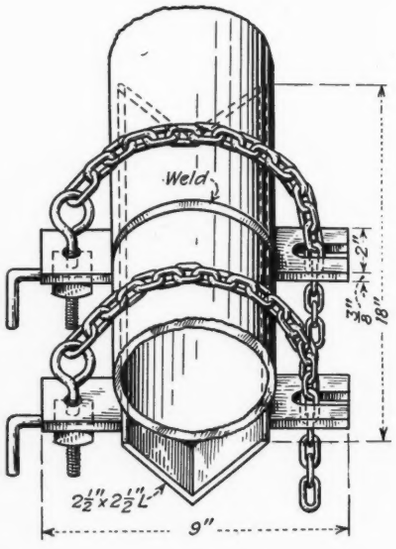
PRACTICAL AIDS TO OPERATION

Handy Clamp Aligns Pipe for Welding

WHEN WELDING PIPE, proper lining-up of different sections and holding them in place until the tack welds are made may be easily and quickly done by the clamp shown in the photo. It consists of two large home-made C-clamps welded, about 12 in. apart, to a section of angle iron. Nuts are welded over holes in the free ends of the C's for the clamping bolts. After the pipe has been tack welded, the clamp may be removed and the welding completed.

Another design of pipe-welding clamp used in shop work is shown in the drawing. This clamp consists primarily of two parallel steel plates connected by welding, 12 to 16 in. apart, to a section of angle iron. Two pieces of chain each connected to an eyebolt complete the clamp. Weld a small piece of welding rod to each eye-bolt nut to form a handle for quick operation of the clamp. Dimensions shown are for pipe sizes up to 3 in. For welding larger sizes of pipe it will be necessary to increase the clamp size.

When adjusting the clamp, place a



⅛ or $\frac{1}{16}$-in. welding rod across the two sides of the angle iron and butt the pipe against it. Tighten the clamp into place and the proper space is maintained between the pipe ends. Then remove the welding rods and make the tack-welds at three points around the pipe.

New York, N. Y. T F LEACH
The Linde Air Products Co

Time Switches Reduce Exterior Lighting Costs

POWER COSTS MONEY and anything that can be done to reduce the amount used without impairing efficiency, means a direct in-the-pocket saving. Controlling illumination systems in line with actual need offers the best possibility of effecting savings. Manual control of outdoor lighting systems must necessarily take into account the human factor. Watchmen charged with the duty of turning outside lights on and off ordinarily take care of this chore on their scheduled rounds and as a result lights are often turned on before they are needed and put out long after daylight makes them unnecessary.

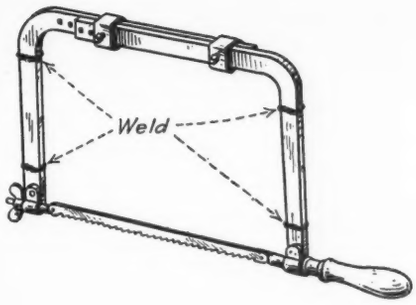
Realizing the waste due to haphazard manual lighting control, a large chemical company has equipped all of its out-

side lighting circuits with time switches. These switches are arranged so that variations in seasonal periods of light and darkness are compensated for. Time switches on display lighting are adjusted to take advantage of that portion of the evening when maximum advertising value is obtained and set to turn off the current during the late hours when few people are about. This method of control has resulted in power savings of 15 to 20%, a sizeable amount when a current consumption of about 100 kw is required for exterior lighting.

Chicago, Ill. R C HENDERSON

Make Hacksaw Do More Work

A HACKSAW is one of the most handy metal-cutting tools, but there are lots of places where you cannot use an ordinary hacksaw frame. For these special jobs I cut the fitting off an old frame



and then welded in sections, see sketch. This extended frame permits getting the saw blade in a lot of places not possible with the standard frame.

Kearney, Neb. ED SWAN

Watch Pressure on Thermostatic Traps

THERMOSTATIC TRAPS offer the simplest, cheapest, and often the most effective method of drawing small quantities of condensate from building-heating or industrial-process equipment using steam at comparatively low pressure. We have found that the greatest single cause of thermostatic-trap failures in industrial service is excessive pressure on actuating mechanisms.

These traps are built to operate within limits set by a given temperature and pressure range. When the upper limit is exceeded, the trap just refuses to open or close until the pressure drops. As frequently happens, the expansion element is strained or ruptured, ruining the trap for service until the element is replaced. This trouble is no fault of the trap. When the external pressure rises above a given range limit, there is not sufficient pressure differential to move the valve in the proper direction. Should the internal pressure rise faster than the external the differential may be sufficient to injure the bellows.

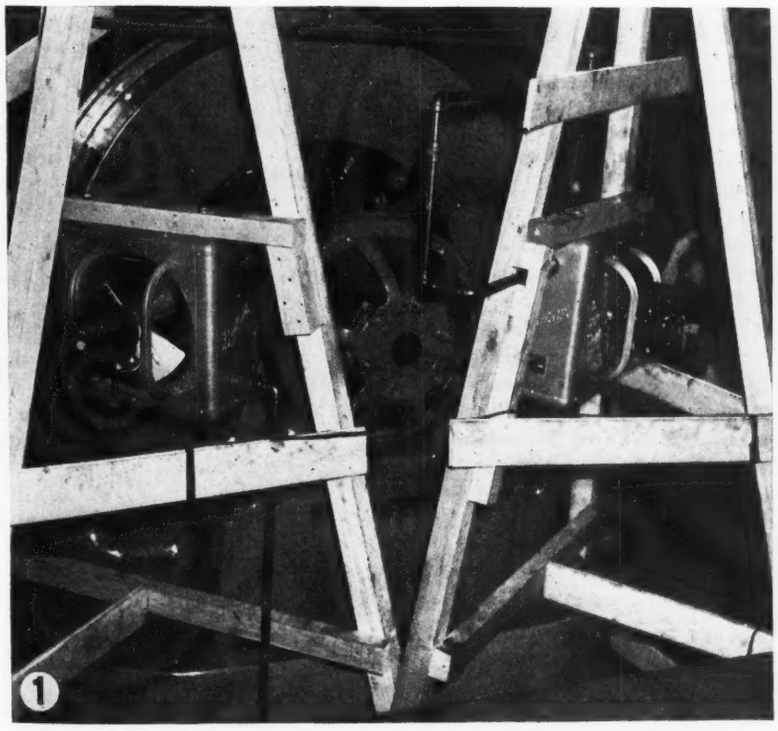
When selecting thermostatic traps for a given application, it is well to re-

Unit Heaters Solve Motor-Drying Problem

WHEN A VALVE in a 60-in. water main burst recently at the Col Francis G Ward pumping station, Buffalo, N. Y., part of the city was without water until another pumping plant could be put into service. Worse still, pump motors and the major part of all electrical equipment in the station was 6 to 10 ft under water. Water was first pumped out by the fire department preparatory to drying out the equipment, which was started the next day after the valve failed.

To dry out the pump motors we installed 11 unit heaters. Fig. 1 shows two of them mounted on temporary frames on one motor. These heaters blew hot air into the water-soaked motor windings and other equipment that needed drying. Canvas hoods placed over the heaters and motors confined the heat where it was required. Of course, proper ventilation from under these hoods was provided so that the moist air could escape readily.

Buffalo, N. Y. F B STUBINGER
Buffalo Forge Co



member that a trap designed for a maximum pressure of 0 to 15 lb cannot be expected to perform satisfactorily when subjected to double that pressure and that traps designed for 70–100 lb cannot be used in 150-lb service.

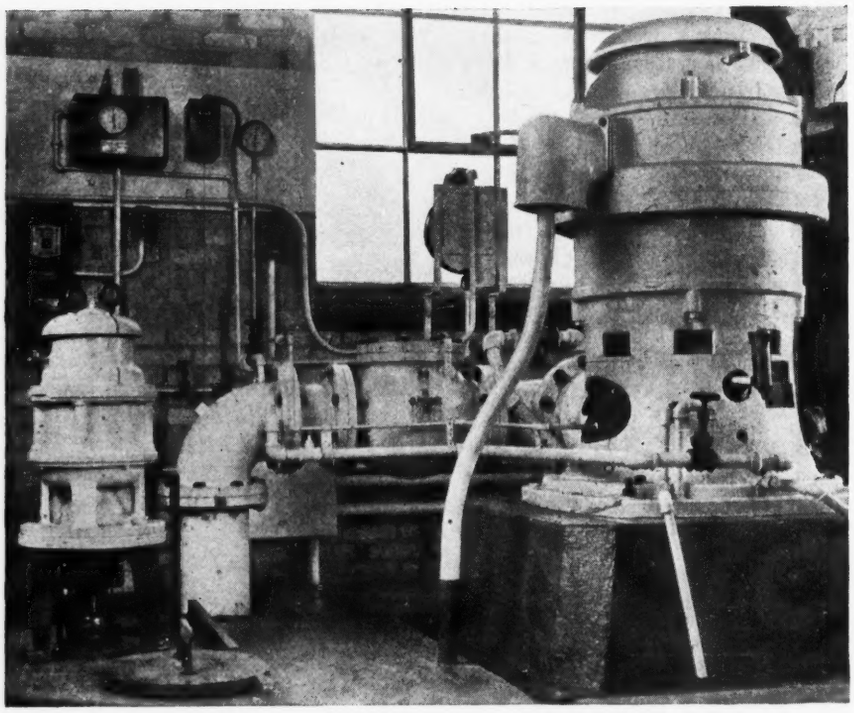
Bethesda, Md. S H COLEMAN

Coal-Tower Maintenance Cut $950 a Year

A GAS COMPANY was faced with a coal-tower maintenance problem which was costing about $1000 a year. The grab-bucket hoist in the coal tower made two to three round trips per minute and required four to six applications of the brake in the same period. With the type of electric brake and brake wheel used, the wheel had to be removed and machined every few weeks. Cost of repairing brake wheel and brake was high.

To improve service and reduce repair costs, the gas company put in a new brake wheel made of molybdenum cast iron and a "thrustor" (electric-hydraulic) electric brake at a cost of $500. Since their installation three years ago, repair cost has averaged $50 per year, a saving of $950 per year. In addition, smoother operation is obtained and more tonnage is handled. Reduction in maintenance costs alone paid for the new installation in less than seven months after installation.

New York, N. Y. A P DANZ
General Electric Co.



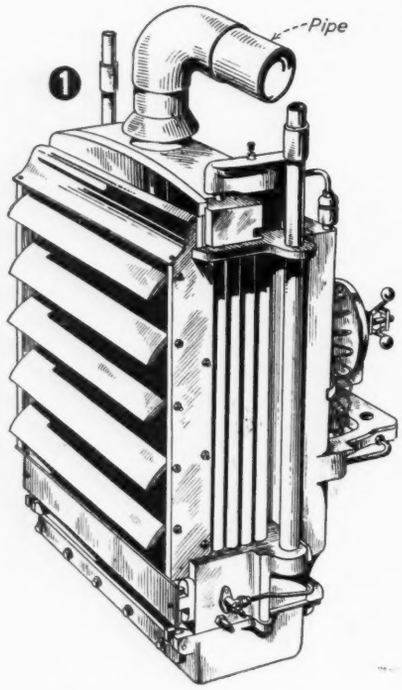
Pressure Gage Shows Well-Pump Operation

OUR DEEP WELL PUMP is in a building some distance away from the power house in a place not always convenient to get to because of a railroad yard. On several occasions, the pump shut down without anyone being aware of it until the low-water alarm began to ring.

A window in the pump house can be easily seen from the power-house operating room so we installed a pressure gage, facing outward, in the window (see photo) and connected it into the pump-discharge pipe. A lamp, properly shaded, was installed above the gage to illuminate its dial at night. Now, when the power-house operator wishes to know if the pump is running, either day or night, he takes a long-range look at the gage.

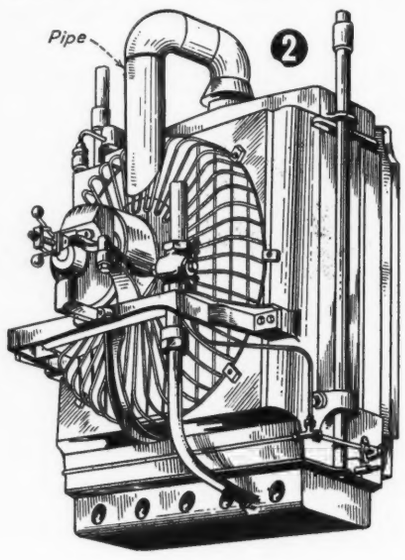
Richmond, Va. C R ROBERTS

Gas Units Solve Factory Heating Problem



BECAUSE OUR BUILDING is not heated during weekend shutdowns we use gas unit heaters in some departments on the top floor to supplement the regular steam-heating system. These departments used to be very difficult to heat up for Monday morning. To heat them properly required turning on steam at 10 o'clock Sunday night, but this overheated the rest of the building. To eliminate the trouble required either revamping the whole heating system or installing gas auxiliary heaters. We selected gas heaters and now the building can be satisfactorily heated after a week-end shutdown by turning steam on at 4:30 Monday morning.

The gas heaters were installed close to the concrete roof and ventilated into the room. At first a stove-pipe elbow was placed on the heater vent, Fig. 1, to turn the burned gas away from the roof. On specially cold days we were troubled with hot gas causing objectionable condensation on the ceiling. I overcame this difficulty by extending the vent pipe directly behind the fan grille, Fig. 2. Now, gas is drawn down-



ward and thoroughly mixed with the air going through the fan and heater; we have no more trouble with condensation.

Englewood, N. J. R BOETTINGER

Breaking-in Period Prolongs Packing Life

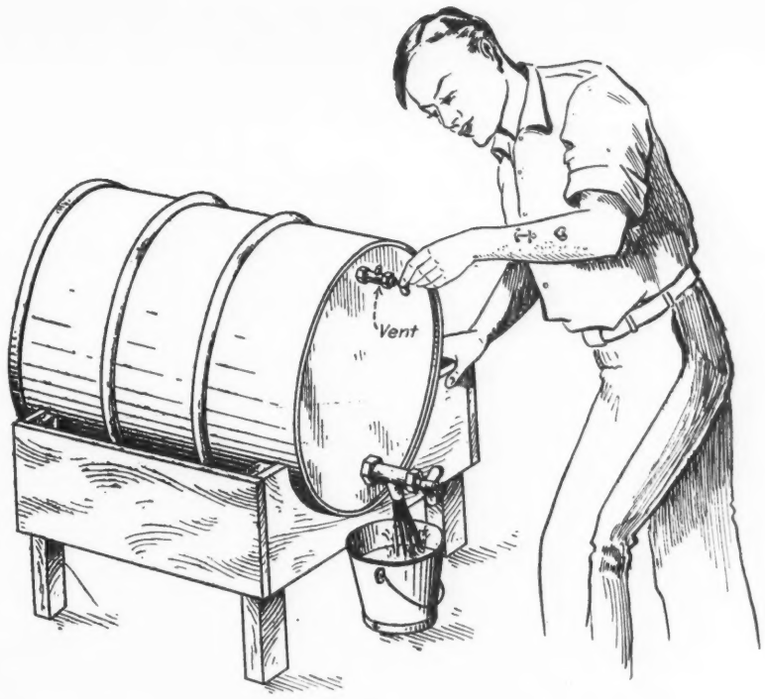
PACKING should be regarded as a type of machine and carefully broken in before setting the gland in its final position. On our oil-pipeline pumps, handling crude petroleum at pressures up to 800 lb per sq in., packing life has been more than doubled by doing this. When we first put in new packing into a pump the gland nuts are set up lightly to give uniform pressure. Spacing of the gland from pump head is carefully checked with calipers. Holding light

pressure on the packing permits it to shift slightly to a good fit.

The adjusting nuts are prevented from turning by an old hacksaw blade, slipped over the wiper gland and under a pair of nuts, Fig. 1. Spring of the blade is sufficient to prevent turning of the nuts, while the saw teeth grip gland and nuts and prevent the blade from being dislodged.

Although the packing used is impregnated with lubricant we find that addition of oil during the breaking-in process greatly extends packing life, especially when used on plungers handling non-lubricant fluids such as kerosene and gasoline. This extra lubricant is supplied to the top side of the plunger by a small pad of absorbent cloth, held in place by the hacksaw blade, Fig. 2. Oil placed on this pad feeds gradually to the plunger and is distributed around its entire circumference. We have found that this auxiliary oiling can be dispensed with after a preliminary period of adjustment.

Longview, Texas M T PATE



Faucet Vent for Oil Barrels

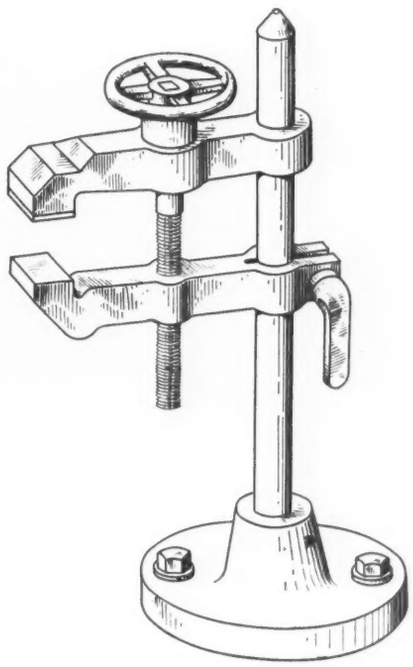
FINDING IT DIFFICULT to vent oil drums that had both openings in the head, we decided to try a faucet for a vent and it worked out fine. To do this, place a faucet in each opening before placing the barrel on the horse. If the liquid refuses to flow open the top cock for a vent. This will keep your barrel clean as the liquid will not escape from the faucet as it does when the bung is removed or loosened to admit air into the drum.

Stafford Springs, Conn. W A SPELLMAN

Floor Vise for Large Parts

ONE OF THE HANDIEST TOOLS in our maintenance shop is the home-made floor-clamp stand shown in the figure. It consists of a large-diameter cast-iron flange for a base, a 4-ft length of 2-in. shafting, and two forged and machined jaws. The jaws will hold most any bulky object too large for the bench vise. To adjust to a convenient working position, raise or lower the bottom jaw on the shaft.

Penacook, N. H. C H WILLEY



READERS' PROBLEMS

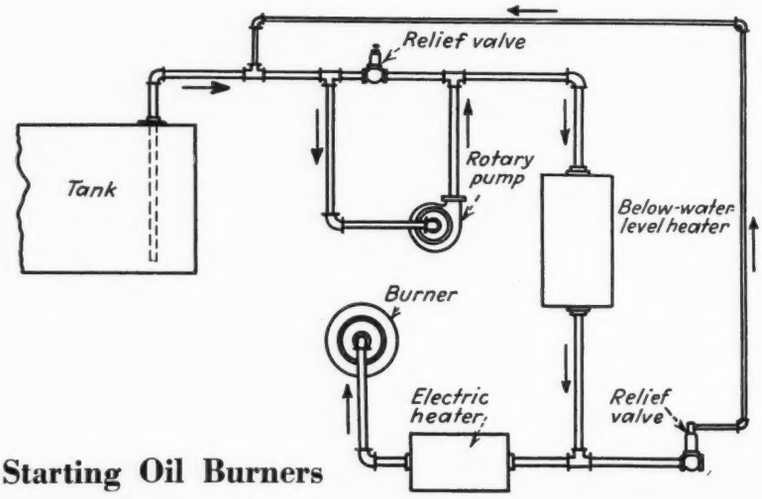
Questions from Our Readers

Turbine Exhaust Pressure

Question 1

IN TAKING ROUTINE DATA *on turbine operation, we instruct the turbine operators to compute the absolute backpressure by taking the difference between the barometric pressure and the mercury-column vacuum gage. There are, however, two other ways of determining the exhaust pressure; by simply reading the absolute-backpressure mercury-column gage, or by observing the temperature of the exhaust steam and determining the absolute pressure, in inches of mercury, from the steam tables.*

In checking these three methods we find that they do not agree, although the two gages are tapped into the condenser at the same point. The "temperature" method, naturally, indicates a higher backpressure than the gages, since leaving losses increase the steam temperature. We would like to get information as to which method is to be preferred.—EWR



Starting Oil Burners

Question 2

THE SKETCH SHOWS *the oil-piping system for a low-pressure heating boiler using Bunker C. No heat is supplied at night, except to prevent freeze-ups in severe weather. When the thermostat calls for heat in the morning, we have trouble getting the burner started because the below-the-water-level heater is practically inoperative until the boiler gets going. Is there any way we can change this hookup to heat the oil before the boiler starts, or is there any other solution?*—PNN.

SUITABLE answers from readers will be paid for if space is available for publication. Answers accompanied by practical drawings or photographs will command additional pay.

Oil-Tank Heater

Answers to Feb Question 1

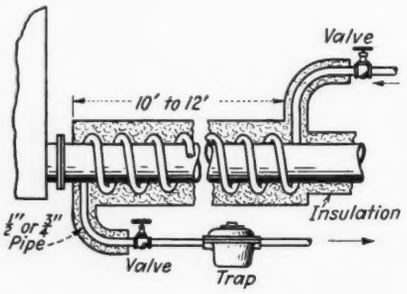
The Question

PERHAPS *some* POWER *readers can offer suggestions on making and installing a temporary steam heater for our fuel-oil storage tank. In our set-up, a duplex pump, connected close to the 50,000-gal tank, forces oil 375 ft to the powerhouse supply tank, which is elevated 24 ft. When the storage tank was built there were steam coils in the bottom and we had no trouble pumping this distance. However, someone was careless about draining and blowing out these lines in winter months and they were damaged and are now useless. With cold oil, we have pumping trouble.*

Recently, I made a heater of ¾-in. pipe coil, 14-in. dia, containing 26 ft of pipe. This was lowered into the tank directly in front of the pump suction, through a 16 x 16-in. opening in the roof. I am not getting results from this heater arrangement, as the warm oil rises to the top, leaving the heavy, cold oil at the suction opening.—MM

Coil Around Suction

I SUGGEST that MM wrap a coil of ½-in. or ¾-in. iron pipe around the suction header between tank and pump. If there is enough room, extend the coil along about



10-12 ft, then cover it with asbestos. On the condensate side install a trap to recover condensate, or drip to waste if preferred. A valve on the steam side will help control temperature of oil at the pump.

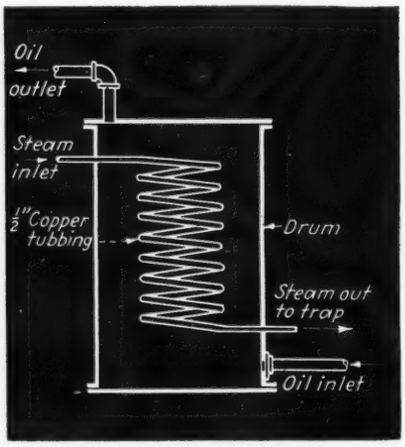
The sketch shows the general arrangement, and the asbestos covering, which should extend along the suction line to the pump. This set-up will serve as a permanent heater and can be made at low cost from materials found around the plant.

Beaumont, Texas G F BRILL

Box Around Coil

MM'S TROUBLE is exactly like a problem I overcame recently. The answer was a box around the coil, with an opening for a swing joint. The sketch shows a coil of 1-in. wrought-iron pipe bent in a spiral to give 6½ complete coils, with a height of about 24 in. The 1-in. pipe rises to go out through the top of the tank, with a trap outside. High-pressure steam is used. We made the housing of ⅛-in. steel plate on 1½x1½-in. angle legs and provided an opening for a swing joint. The swing joint is operated by a chain from a manhole on top of the tank and permits raising or lowering the heating coil to the point where it will do the most good.

This set-up works satisfactorily on a 50,000-gal tank, with a 2-in. pipeline running to duplex pumps 370 ft away. With an average outside temperature of 0 F, temperature in the line at the pump hits about 125 F. A boxed-in pipe duct, run-



ning above ground, houses the pump suction line, the high-pressure steam line to the coil, and the return line.

Ontario, Canada C A BAKER

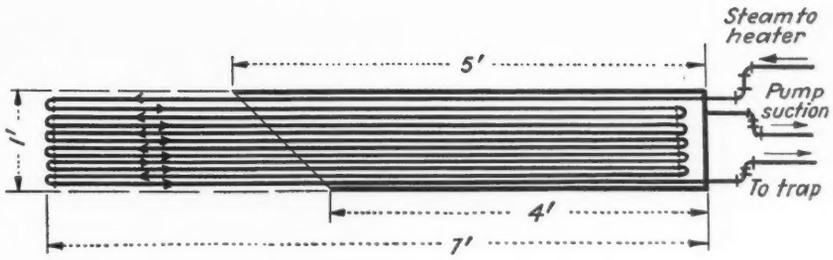
Make Folding Box

FROM THE WORDING of MM's question, it looks as if the problem must be solved without emptying the tank or shutting down, and there is only a 16-in. square opening through which to work. Apparently, the heating-coil steam and return lines go through this opening. As the coil is close to the suction and has been lowered into the tank, I suggest inclosing the coil in a 3-sided sheet-metal box, as shown in the sketch.

The sides of this box are hinged so that they fold together to permit entering the tank diagonally through the opening. The top must be made in two halves and cut to clear the pipelines. Use 1/16-in. material and rivet a length of $\frac{3}{4}$-in. angle iron along the top of each of the 3 plates to take $\frac{3}{8}$-in. screws for the top. Put the three sides through the manhole, open out, and insert eyebolts in holes for easy handling. When eyebolts are secured with nuts and washers, suspend the three sides within easy reach while the top of the box is put in place.

The whole thing can then be lowered into the tank where it will sit on the bottom. The eyebolts remain in the box, of course, and the tackle is unhooked by lowering the hooks. This arrangement will keep the hot oil confined around the suction pipe and should prove helpful.

Kearny, N. J. GEORGE MCNALLY



Use Refinery Heater

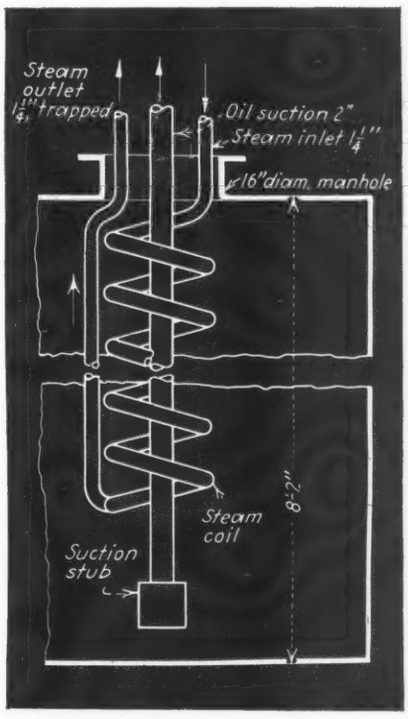
MM MIGHT TRY MAKING UP a heater similar to those used in refineries for pumping heavy oils, and insert it through the top manhole of the tank. These heaters consist of a bundle of steam pipes surrounded, for about 2/3 of their length, by a casing closed at one end with a flange carrying oil-suction and steam connections, designed to fit the lower manhole of the tank.

In MM's case, I suggest he make up a pipe bundle, say $\frac{3}{4}$ or 1-in. with return bends, having a diameter of 12 in. and a length of 7 ft. Slip a steel casing over about 5 ft. of this bundle, weld a plate over one end and make connections for steam pipes and oil suction. By means of swing joints, connect the steam lines and pump suction to these connections and lower heater through the manhole. After tank has been pumped out, the heater could be properly attached to the lower manhole, if desired.

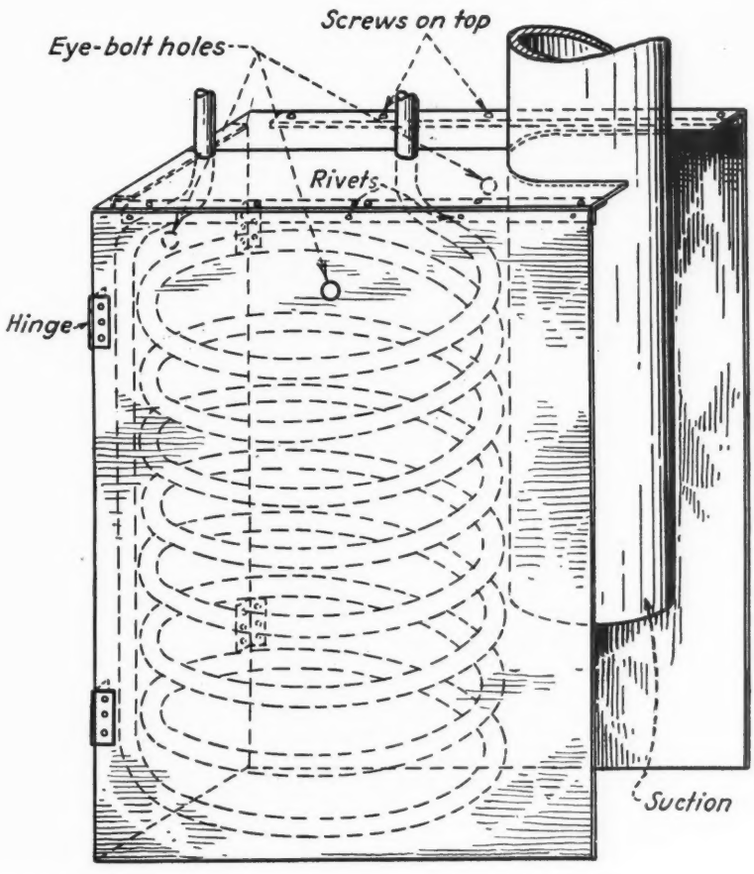
Moosejaw, Saskatchewan H C YEO

Simple Coil

THE SKETCH SHOWS the simple iron-pipe coil in the 5000-gal. tank that serves our boilers. This $1\frac{1}{2}$-in. coil extends to within a foot of the tank bottom, and surrounds the suction stub. The tank is under the alley, in an unheated room. Handling about 3000 gal. of Bunker C every day, with demands as high as 160 per hr, this set-up keeps oil in the suction line to the reheater at 140 F at all times, using 100-lb steam. We never had any trouble keeping the oil hot, or with plugged lines. I believe the $\frac{3}{4}$-in. line that MM speaks of is too small to do much good.



Maywood, Ill. G W REDMAN

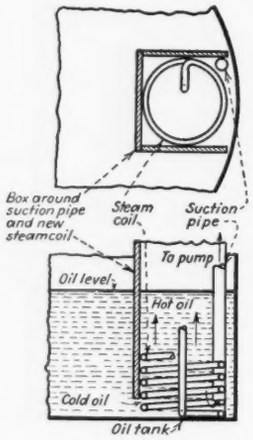


Put Wooden Box Around Coil

I SUGGEST building a wooden box around the new heating coil and suction pipe (see sketch on next page). Any other insulating material can be used, of course. This box can be lowered through the present opening in the tank and should be built high enough to prevent warm oil from flowing away. A clearance of 8 to 10 in. in the front and bottom of the box

should allow sufficient inflow. Ordinarily, heating coils in oil tanks are closed in with horizontal boxes to secure flow of warm oil to the suction inlet. This vertical box seems to me worth trying.

Fair Lawn, N. J. F C RAGG



Heater in Manhole

MM'S PROBLEM closely resembles one I faced recently, except that his set-up is temporary. Standard heaters are available, designed to fit into the manhole usually located near the tank bottom. These heaters are made with a flanged connection which bolts into the existing drilling at the tank flange. All you have to do is remove the manhole cover, insert the heater, and bolt up. Of course, a temporary steam heater can be designed along the same lines. However, MM must remember that this type of heater can only be installed with tank practically empty.

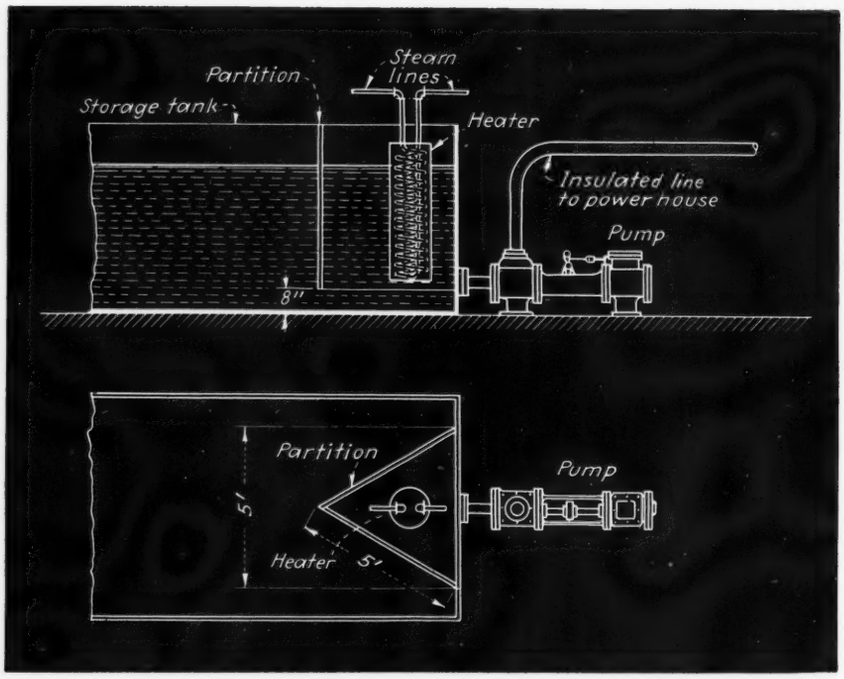
Kansas City, Mo. S L KRECHEFSKY

Swinging Suction Pipe

WHEN HEATED OIL floats to the top and cold oil goes to the suction, it indicates a heater that is too small. I suggest extending the suction pipe by addition of two ells, a short nipple, and a length of pipe. Attach an ell to the lower end of the suction-pipe extension, making up a tight joint. Attach the other ell and the short nipple to the lower end of the existing suction pipe, also with tight joints.

Then fit the extension pipe, with its ell, to the short nipple, taking up just enough on the connection to leave it able to turn. By means of a float, the suction pipe can be raised and lowered with the oil level, always taking warm oil from a point a few inches below the oil level. This arrangement worked for 7 months in our plant until we got a larger unit.

Philadelphia, Pa. W T MULLEN



Put Partition in Tank

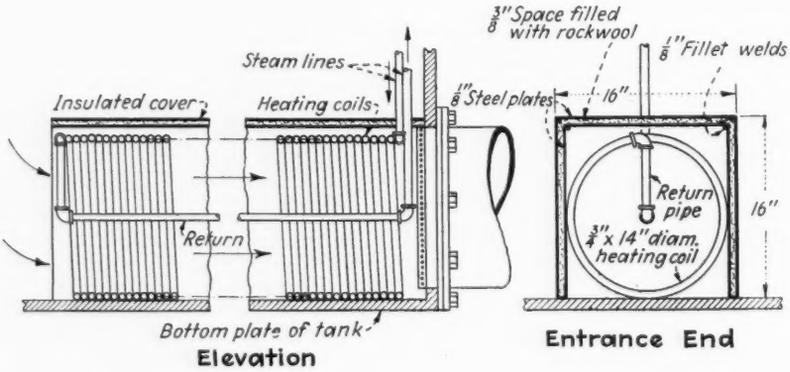
A SIMPLE WAY to raise oil in the storage tank to a temperature suitable for transportation over a long distance is to put a partition in the tank as shown in the sketch. This section will contain approximately 700-1000 gal and the existing heater will be large enough to keep oil in this section warm at all times. The pipe from the pump to the powerhouse should be insulated if air temperature in winter months gets very low.

Vancouver, B. C. A KAPLAN

Cover Heating Coil

I THINK MM should cover his heater as shown in the sketch. With an insulated cover, the oil will be heated as it flows through the coil to the suction entrance. The warm oil cannot rise to the top of the tank; it will flow horizontally through the heater. However, before going ahead, MM must consider whether the opening in the top of the tank can be enlarged to admit heater cover. He should also work out the heat-transfer angles carefully.

Troy, New York B D OSBORNE



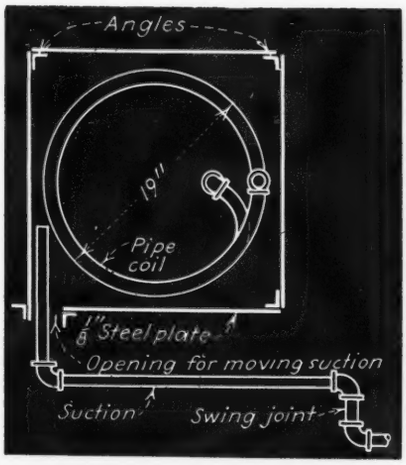
Heater from Drum

MM SHOULD MAKE a simple and inexpensive oil heater to use between the main oil tank and the pump, until such time as he can empty the oil tank and get into it to work. The sketch shows a satisfactory arrangement, made from a 50-gal steel drum with a copper heating coil in it.

Cut out the top, burn holes in the sides of the drum for the tubing, set the coil in place, and braze it to the drum. Weld a nipple to the side for an oil inlet and braze the cover back on the drum. The existing connection on the drum forms an oil outlet. Use compression fittings to connect the tubing to an l-p steamline.

Not knowing the capacity of MM's pumping set, I estimate that with a 50,000-gal storage tank, he pumps a maximum of 500 gal per hr. To heat this oil from 60 to 100 F, which should be enough for pumping, would require about 75,000 Btu per hr. Using low-pressure steam, he would need about 15 sq ft of heating surface, equivalent to about 120 ft of ½-in. copper tubing. The heater should be as close to the pump as possible. If higher than the tank, no valve is needed between heater and tank. If a valve is put in that line, a relief valve is needed at the tank.

Staten Island, N. Y. R A ATLAS



Use Shell Heater in Suction Line

MOST ECONOMICAL RESULTS will come from enclosing the steam coil in a shell and installing the heater in the pump suction line near the storage tank. In designing a suitable heater, give careful consideration to providing enough heating surface. There are too many unknown factors to check whether 26 ft of ¾-in. pipe will do the trick, but a rough estimate of MM's problem indicates there is only enough surface to heat 3 gpm of 18 API oil (8 lb per gal, specific heat 0.50) from 50 to 90 F, assuming 298 F steam temperature, (50 lb g), 70 F mean temperature of oil and a heat transmission of 0.3 Btu per min per sq per F:

$$\frac{(298 - 70) \times 7 \times 0.3}{0.50 \times 40 \times 8} = 2.99 \text{ gpm}$$

If oil is pumped rapidly, and only at intervals to replenish the running supply tank, the heater shell should be large enough to hold the amount of oil handled during each pumping operation. The steam should be turned on when the pump is idle in order to heat another batch.

Fresno, Calif. E H CARLSON

More "Mileage" from Diesel Lube Oil

The Question

WE ONLY GET *about a 1000 rated bhphr per gal of lubricating oil on our 450-hp diesel. Will a wiper ring on the skirt and another replacing the lowest of the four rings on the crown improve this performance? What other steps could we take to get more "mileage" out of lube oil?*—CCD

Path for Oil Escape

I AM INCLINED TO BELIEVE CCD will get more lube-oil "mileage" if he will provide a path of escape for the oil by means of two ring grooves. Since no details of the engine are given, it isn't possible to make an exact recommendation, but the scheme is presented for what it is worth.

On our slow-speed air-injection engines, which have piston diameters of 11.75 in. and 13 in., and are rated at 180 bph and 450 bhp, we drill holes in all new pistons before installation. This drains excess oil from the cylinder walls. We also use double-seal piston rings, usually three on each piston. On a new piston we insert one or two used double-seal rings the first year.

Wisner, Neb. A K GENTZLER

Find Cause of Trouble

IN ANSWERING CCD's question about high lube-oil consumption, we have to assume that his engine is a comparatively high speed unit of 4-cycle design, using a good grade of lubricating oil. Other possibilities beside piston-ring changes must be considered first. High intake-air restriction, high crankcase pressure or vacuum, high backpressure on exhaust, dirtiness of oil, bearing clearances, and water scale, all affect the oil consumption more or less. If these have been checked and found normal, perhaps baffling the oil throw-off in the crankcase may help in keeping down excess oil.

Consideration of the present type of oil ring should be the next step. If a slotted type, having drainage through the center of the ring (*A*), is used, changing over to the more effective scraper type (*B*) should help. With this type of oil ring, additional drain holes should be drilled (*C*) in order to do a good job. The next step would be to try a slightly less effective oil ring in the groove above the wristpin and also drill drain holes (*C*). I strongly recommend using a 2-piece sealing ring in grooves *2* and *3*, to prevent pressure from leaking by the three compression rings that would be left if an oil ring were used in the groove above the wristpin.

If this ring combination fails to give the results wanted, a spring behind the oil rings might give them the wall pressure needed to obtain control. This is only recommended as a last resort, as use of springs will cause excessive wear of the oil rings.

Chicago, Ill. C K FEYEN

No Scraper Ring

ACCORDING TO MY EXPERIENCE, it is best not to use a scraper or wiper ring on the piston skirt. Instead, use a good ventilated oil ring. Be sure that the groove for the oil ring is slightly deeper than the other grooves. Several small holes should be drilled in the bottom of the groove, so oil can drain. I don't recommend a scraper because it is more than apt to do a good job of scraping the oil from the cylinder wall, thereby robbing the other rings of lubrication, causing them to wear faster than they should, causing "blow-by", making the rings run hotter than they should, and further ruining the lubrication of the piston.

A scraper could be used in the bottom groove of the four upper ring grooves, but again I would suggest a good oil ring, making sure the groove was deeper and drain holes provided. However, it is in grooves *2* and *3*, and possibly the first, where CCD should try to cut oil consumption and stop blow-by. To do this, he should install the best 2-piece rings in grooves *2* and *3*. He should make sure that the shoulders of the ring land are absolutely true. Under most conditions, I would not recommend using a 2-piece ring in the first groove, for it would only be a short time before the ring would stick and therefore would not function. I would use, instead, a good plain ring, making sure it fitted the groove correctly and that the end clearance was right, determined from the piston diameter.

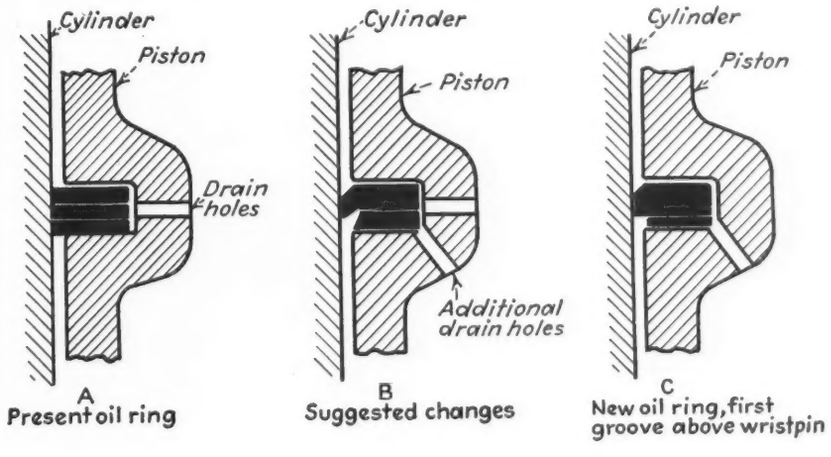
Bismarck, N. D. LESLIE BRADLEY

Drastic Measures

I DO NOT BELIEVE CCD would have much success in saving lube oil by merely replacing the wiper rings. The condition he describes is too severe and needs more drastic measures. The engine consumes a gal of oil per 1000 bhphr. That is better than 10 gal per day and, assuming a good grade of oil is used at $.50 per gal., it follows that it costs $5.00 per day or $1825 per yr, for oil.

I recommend new liners, new rings, and having the ring grooves re-trued. The saving in oil would soon pay for the parts, assuming the engine operates through a major part of the year. On the other hand, if used for standby, I would say that a new set of rings would be enough. Using 2-piece, double-seal rings, or common rings with expanders will greatly reduce oil consumption.

Fresno, Calif. C I WOODS



ARGUMENT CORNER

What is Efficiency?

MANY ENGINEERS complain that management has a habit of discounting efficiency; that to some executives the word efficiency is as irritating as a red flag to a bull. We meet this attitude too frequently to dismiss it as a personal whim of this man or that man, and it is quite possible that the difficulty lies in misunderstanding of efficiency figures.

For instance, the ASME Boiler Code defines efficiency as the heat in the steam produced by a boiler divided by the heat in the coal burned. However, an executive who uses this efficiency to determine how much steam he will get from a certain quantity of coal will find himself in trouble, for this is what might be termed a gross efficiency, rather than a net efficiency. It takes a certain additional amount of steam to produce the power required by the forced- and induced-draft fans and by the stoker or pulverizer. This might be called the "coal equivalent to operate" and really should be taken into consideration when discussing efficiency. After all the management wants to know *net* efficiency, which expresses amount of steam available for work *outside the boiler room.*

The practical value of using net efficiency shows up in comparing various types of boiler equipment, methods of firing, etc. Take the hp required for fans, and for coal preparation and burning, and transform the total into lb of coal per hr. Add this to the amount of coal to be burned in the furnace to produce the net steam requirements, and then figure efficiency. This gives a true comparison, to my way of thinking. If efficiencies were figured in this manner we might not be so casual in talking about 89–90% boiler efficiency, as net efficiencies are considerably lower, and the figures would represent more nearly the efficiency a manager can expect to get. Perhaps this plan would help dispel the shadow that has fallen on that useful word efficiency.

Pittsburgh, Pa. G D BRADSHAW

Scotsman's Goat

In the February issue of POWER I read the article, "Plan Your Way Out of Trouble." That paper was, in a way, satisfactory, but when it ended with reference to a "Scotchman," that got my goat.

You see, when I came to this country almost 17 years ago, I read in mechanical magazines some balderdash about "American High-Pressure Practice as Compared with European Low-Pressure Practice," and lots of other high falutin' titles.

When the hulk I sailed on arrived in Boston Harbor, I happened to be between decks at the time. Suddenly I heard the exhaust of a steam engine puffing somewhere. Thinking it to be a locomotive, I beat for the deck, and, much to my disgust, I found it to be a tugboat. What unholy thing was this? There were others on the deck beside myself, who passed unsavory remarks about that tug-boat exhausting into the atmosphere. Such stuff wasn't done in Scotland. Jimmie Watt invented the condenser. . . .

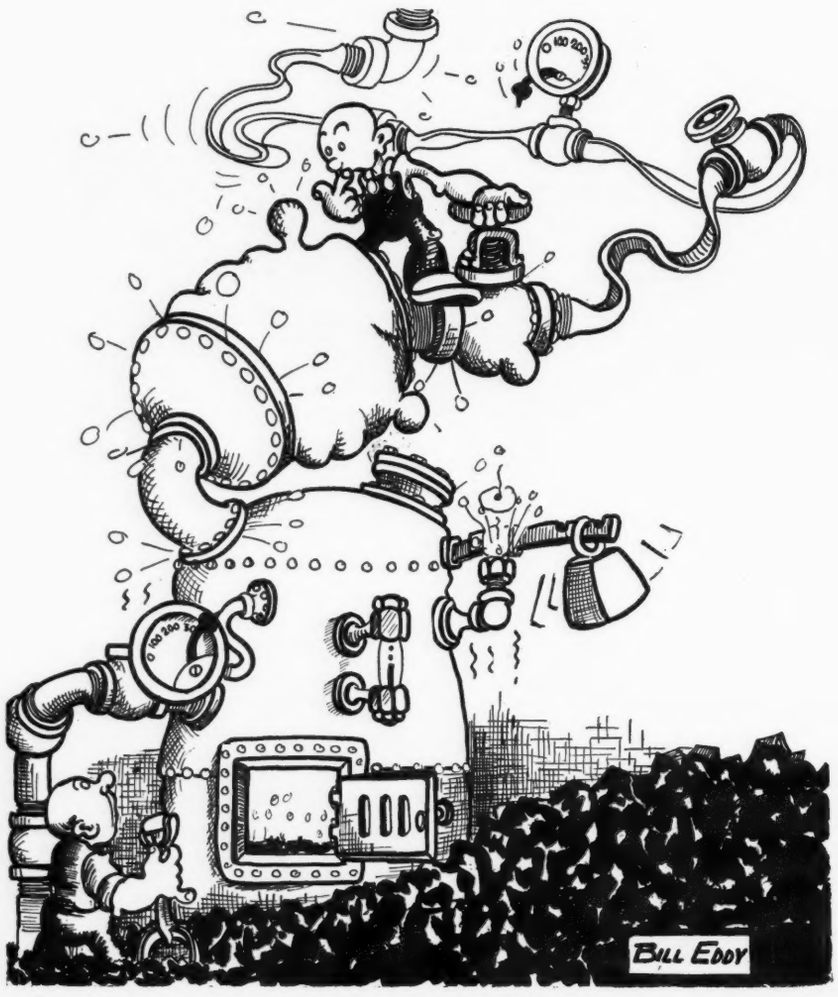
As we were getting nosed into the pier, a cry went up, and still more laughing. And no wonder, as there coming up the bay was a sight that would have made Watt or Telford themselves grin, for rocking above the decks was the spider beam, or rocking beam, if you want to call it that, of a *beam* engine, a contraption that should have been in a museum, a type of engine that was never put in a steam boat since Bell's Comet sailed up the Clyde.

Ashore in Boston, and in other cities, too, it struck me as odd that so much steam should be going to waste from pipes stuck out from tall buildings. "Wasteful practice them there Yanks pursue. . . . ."

The locomotives tickled me pink. I liked to see them, in spite of the fact they were dirty hoblers. Y'see, I had been brought up in a locomotive works, and took a trip to sea "for my health."

In shore power plants I noticed boilers with the fire under the shall, the

(Continued on page 134)



"Hold it, Norbert, while I go get POWER's Data Sheet No. 77-B"

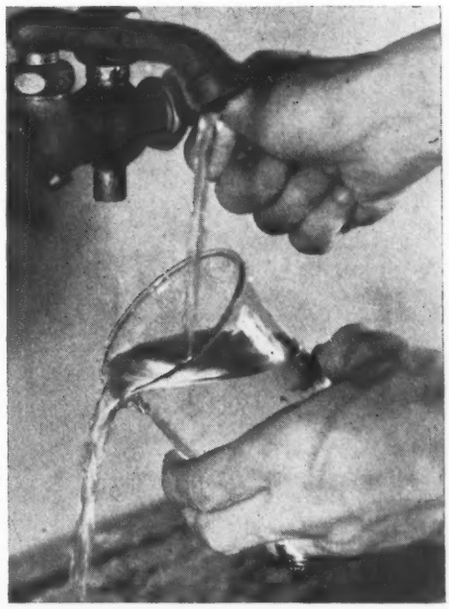
HOW TO TEST FOR ALKALINITY

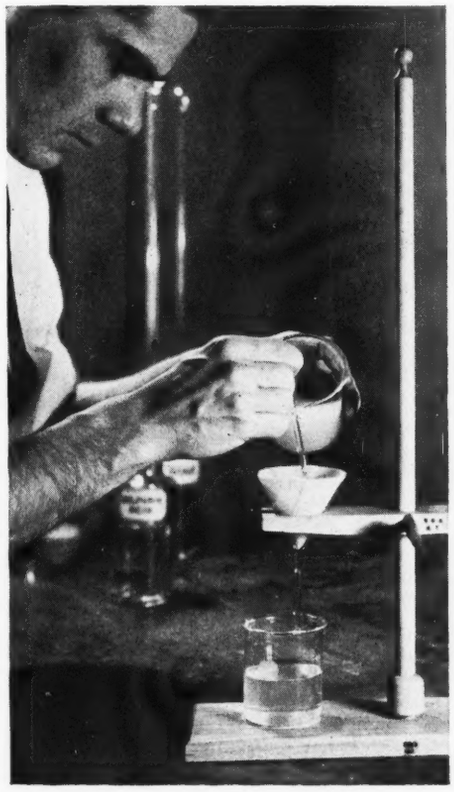
By C A NOLL
Chief Chemist
W H and L D Betz
(*Photos by* POWER)

The three water tests most commonly required in routine power-plant operation are those for hardness, alkalinity and chlorides. The hardness test was described last month. This is the alkalinity test. The chloride test (next month) will complete this series. For description of test kit, and general hints on use, see page 109, February POWER

1 →

Since a clear 50-cc water sample will be required, collect several times that quantity in a beaker or other clean glass container. If the sample is boiler water, or is turbid, allow sludge to settle





← **2**

If water will not settle perfectly clear, pour the top portion through a filter paper to remove all cloudiness

3 →

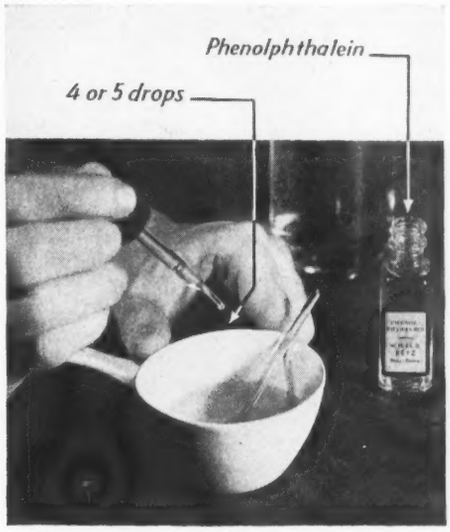
Pour exactly 50-cc of the clear sample into the graduate. Be sure to get the *bottom* of the meniscus (curved liquid surface) exactly level with the 50-cc graduation (all readings on graduate or burette should be made this way for accuracy)

← **4**

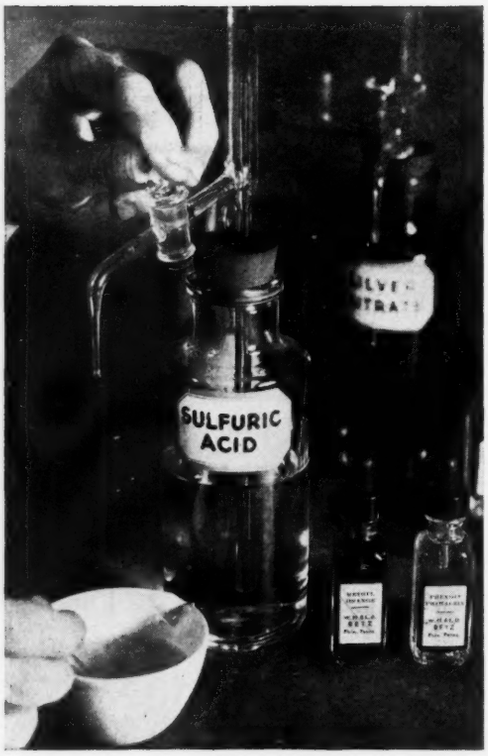
Pour sample into casserole

5 →

Add 4 or 5 drops of phenolphthalein indicator. If the sample is boiler water, it will usually turn red. If the sample is typical raw or natural water it will usually remain colorless when the indicator is added

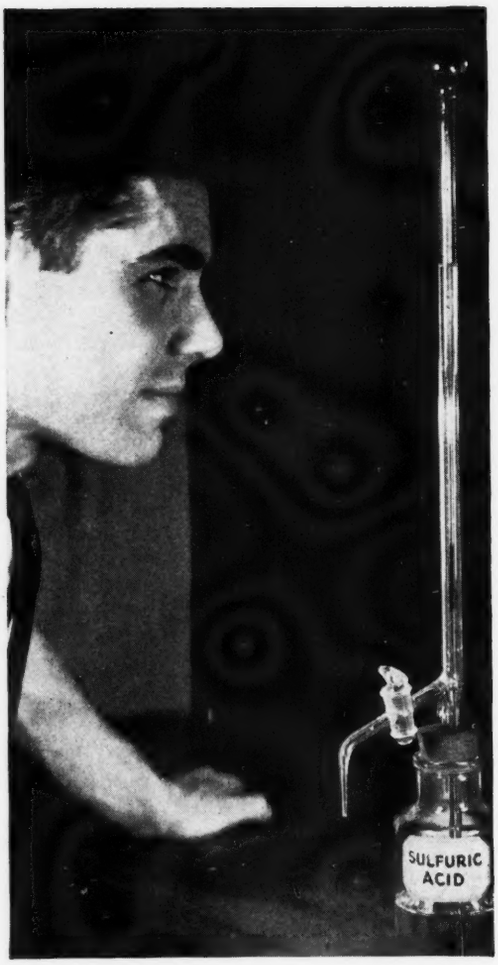


(*Continued on page 114*)



6

Add the standard N/50 sulphuric acid drop by drop to the sample in the casserole, constantly stirring, until one final drop (no more) removes the last trace of red color and the sample becomes colorless

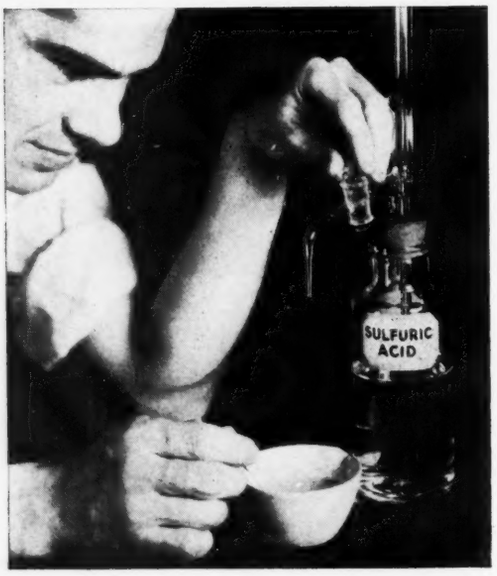


7

Read burette, and record, under the heading "P" the total cc of acid solution used so far in the test

8

Now add 4 drops of methyl-orange indicator (if no red color developed upon the addition of the phenolphthalein indicator to the original sample, see Fig. 5, the titration may be started with the methyl orange at that point, omitting steps 6 and 7). The solution is now yellow tinted



9

Continue adding the acid drop by drop, stirring constantly, until one final drop changes the color from yellow to orange

STEP 10 (NO PHOTO)

Then stop, and record under heading "M" the total amount of acid used *(including that used in the first part of the test)*. To get the "M" reading correctly requires care. Don't add so much acid that the solution goes to a definite red. *Stop at reddish orange.* Note that the "M" reading can never be less than the "P" reading, since the "P" reading is part of the "M" reading

CALCULATION

The figure recorded under "M" is always the "total alkalinity." A chemist can calculate the amounts of the various types of alkalinity present if he is given both the "M" and "P" readings. These readings are multiplied by 20 to give the corresponding results in parts per million.

Example:

First burette reading = "P" = 4.1
Second burette reading = "M" = 6.4
Alkalinity to "P" = 4.1 × 20 = 82 ppm
Alkalinity to "M" = 6.4 × 20 = 128 ppm

THIS is a picture of a rotor from a Fairbanks-Morse Motor

Notice the squirrel cage winding!

It is of copper. The *one* metal most desirable, electrically and mechanically, for meeting the severe service a modern motor must withstand. Copper, the *one* metal of low resistance and low thermal expansion—best able to withstand high temperatures caused by constant plugging and reversing service.

Note further that this copper is *centrifugally cast* into a one-piece winding. *Centrifugally cast* to imbed the winding into the core slots deeply and tightly.

Then, after casting, this rotor is machined and dynamically balanced to the famed Fairbanks-Morse standards of precision.

Only Fairbanks-Morse makes rotors with copper windings which are centrifugally cast. The Copperspun Rotor is an exclusive Fairbanks-Morse development, process, and feature.

For complete information on F-M Motors with Copperspun Rotors, write Fairbanks, Morse and Co., 600 S. Michigan Ave., Chicago, Ill. Branches and service stations throughout the United States and Canada.

7708-EA40.153

FAIRBANKS·MORSE MOTORS

DIESEL ENGINES ELECTRICAL MACHINERY RAILROAD EQUIPMENT WASHERS-IRONERS STOKERS
PUMPS FAIRBANKS SCALES WATER SYSTEMS FARM EQUIPMENT AIR CONDITIONERS

The Eyes Have It

(Continued from page 74)

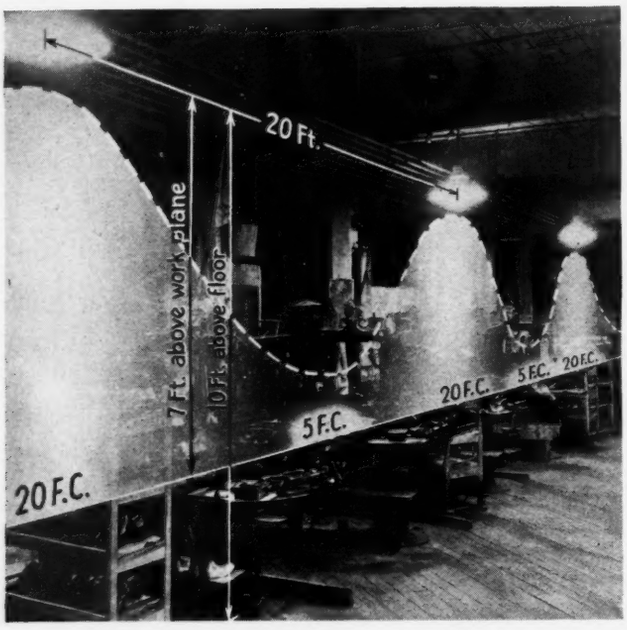


Fig. 3—"Roller-coaster" lighting effect obtained by improper spacing of lights penalizes worker in 5-footcandle area

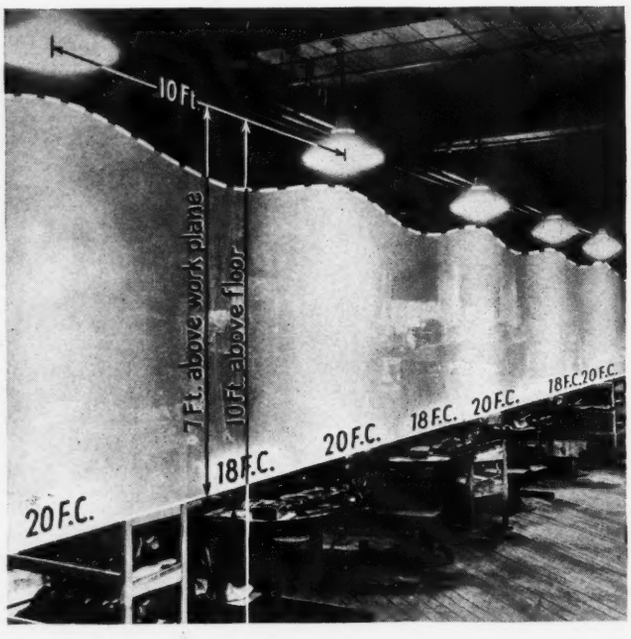


Fig. 4—More even distribution of light results when more lights are added and placed closer together

erned by such considerations rather than first cost alone.

Although there are many different types of equipment employed in the industrial work world today, there are several types made by leading manufacturers that deserve mention.

The RLM standard dome reflector is a porcelain-enameled steel reflector made to rigid specifications. White bowl lamps are recommended, although inside frosted lamps can be used where the mounting height is above 20 ft. In boiler rooms and where coal and ashes are handled, a glass cover should be used to keep reflecting surface clean.

The Glassteel Diffuser unit is quite similar to the RLM, but has two additional features: (1) small openings at the top to allow some of the light to go to the ceiling, and (2) a glass globe inside the reflector which serves to enclose the filament lamp.

In locations such as power plants, where the units are mounted over 20 ft above the floor, special equipment having a relatively concentrated distribution of light is required. These are called high-bay reflectors, and are available in prismatic glass, mirrored glass, and Alzak aluminum.

In the machine shop, especially where critical seeing tasks demand high-level lighting of good quality, special supplementary equipment is employed. One is a small, relatively concentrated unit which is intended to augment the general lighting over restricted work areas, and the second is a large-area, relatively low-brightness source. The latter is of fairly recent origin and consists of large luminous areas generally mounted 3 to 5 ft above the work. These are available in several forms, using both filament and fluorescent lamps.

General lighting service lamps still fulfill 25% of the lamp requirements in industry. They will operate in any burning position, but for best output it is recommended that the larger sizes be burned vertically, base up. The lamps are available in either clear bulb, inside frosted, or white bowl finish.

Mercury Lamps

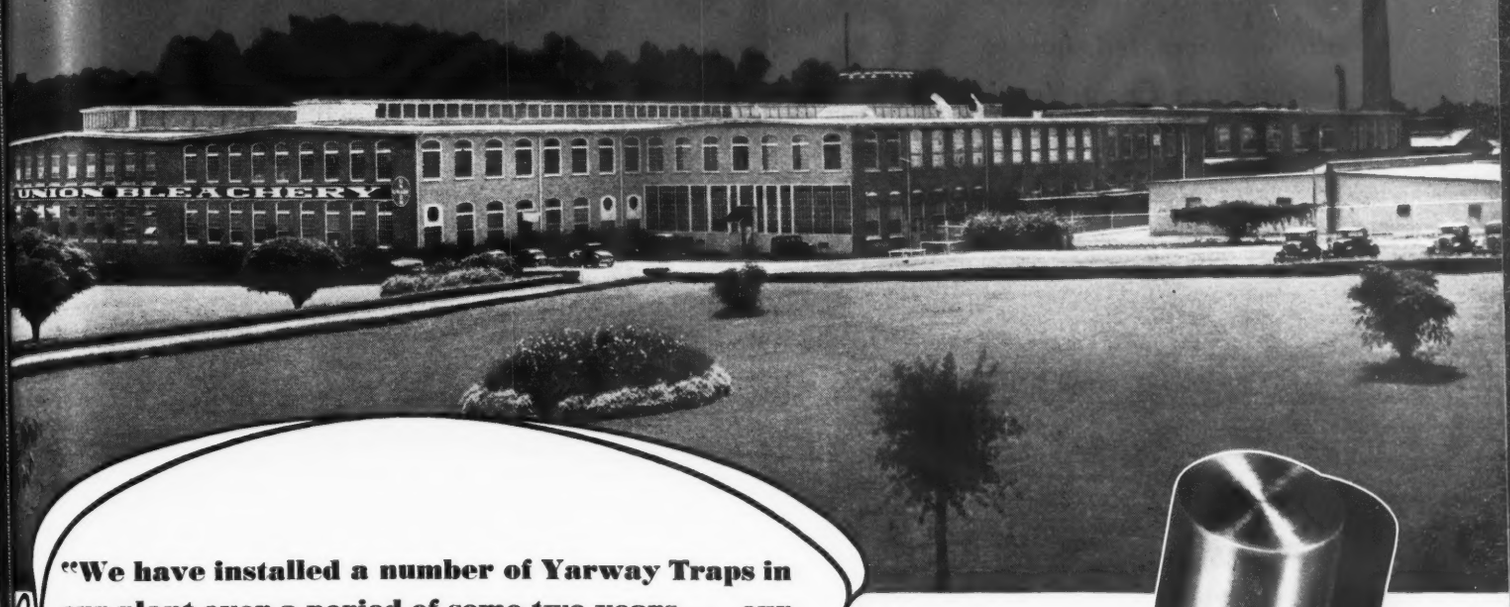
Mercury-type (H) lamps, available in 250- and 400-watt sizes, differ radically in principle from incandescent filament lamps both in their operation and in color quality of the light produced. The principle of operation is that of a mercury vapor arc or flow of current between the two main electrodes at the upper and lower parts of the bulb. The operating characteristics of these lamps are such that they require special regulating devices. A development of importance is a new type of transformer which operates two lamps, although it will operate either satisfactorily alone. Known as the "Tulamp" transformer, it operates the two lamps out of phase, so that on 60-cycle ac, when one lamp is at the low point of the cycle, the other is at the high point. Thus if an area is illuminated equally by two lamps, the stroboscopic effect is minimized.

The fluorescent lamp is of the electric-discharge type, using mercury vapor as the medium for maintaining the arc. The lamps convert invisible ultraviolet energy, produced by the arc, into visible light through fluorescent powders with which the inner surface of the tube is coated. They are tubular in shape and are available in five wattages, five different lengths and three diameters. The table shows essential data of these lamps used for industrial lighting.

Because the fluorescent lamp is an arc source, current-limiting or ballast equipment is needed. Auxiliaries containing both a current-limiting choke coil and a starting switch consume from 15 to 30% as much energy as do the lamps. With present auxiliaries now available, all five of the wattage sizes can be operated from normal 110-125-volt ac circuits, and at power factors of 85 to 100%, designed to operate on 50- and 60-cycle alternating circuits.

Although there are eight colors to choose from, only three are recommended for utilitarian lighting. These are daylight, white and bluish-white. The other colors are red, gold, pink, green, and blue. The light from the daylight lamp is the nearest approach to natural daylight that it has ever been possible to produce directly by an artificial illuminant at high efficiency. These lamps are cool, too, because for equal footcandles the fluorescent lamps radiate only one-quarter as much heat as do filament lamps.

The YARWAY IMPULSE TRAP'S *Small Size and Light Weight* SATISFY UNION BLEACHERY



"We have installed a number of Yarway Traps in our plant over a period of some two years . . . our selection was influenced by the fact that they take up so little room and are of such light weight, that they may be installed conveniently without special support," says Union Bleachery, Greenville, S. C.

•

In many industries, Yarways—the little traps that do the big job in keeping equipment hot—are saving valuable space and reducing installation costs.

That is one of the reasons why hundreds of leading companies have standardized on Yarway Impulse Traps. (More than 60,000 Yarways have been installed.)

Other good reasons are: their quicker heating and greater sustained heating efficiency, low maintenance cost and long life. (Only one moving part.) And when you consider that their purchase price is usually no more than the cost of *repairing* an ordinary trap—why not get Yarway performance for your money?

More than 100 convenient Mill Supply Houses sell Yarway Impulse Traps (sell more of them than of any other Trap on the market). Call your supply house or write for Catalog T-1735.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia

YARWAY IMPULSE STEAM TRAP

Getting the Right Pump Packing

Vincent A R Minter, Charleston, W. Va., experienced operating engineer, tells how to select and install centrifugal-pump packing to get long and satisfactory service

Assign the installation and maintenance of packing to mechanics who take pride in workmanship. They will keep equipment trouble free

▶ In March POWER we considered how to buy pumps. Here we turn our attention to selection of pump packing. An aid in solving this problem is a list of properties of the liquid to be handled and the conditions of packing service. In setting down the properties of a liquid, we should ask ourselves these questions:

1. *Is the liquid clean, free from crystalline or sludgy materials?*
2. *If hot, will the liquid undergo a change of state as it penetrates back into packing?*
3. *Chemically, is it on the alkaline or acid side? If so, what is the degree of alkalinity or acidity?*
4. *Does it possess any lubricating properties? Is it oily? Will it wet the shaft or sleeve material?*
5. *Will it have any solvent action on packing impregnated with lubricants?*

When considering conditions of service, we will ask:

1. *What is the operating temperature of the liquid and packing-box assembly?*
2. *What pressure will be actually on the packing?*
3. *Can some leakage of the liquid be tolerated?*
4. *Is contamination of pumped liquid undesirable?*

Consider each of the above questions. Clarity of the liquid and its freedom from crystals or sludge will have considerable bearing on packing life. It is safe to say that no packing, no matter how good, can stand up in a service in which an abrasive material is constantly working in between it and the shaft sleeve. Similarly, a liquid which solidifies or precipitates crystals after cooling creates a severe, if not impossible, running condition for the packing. Here, solution of the problem involves packing selection and provision for a backwash through the packing of a suitable liquid or lubricant.

Whether the liquid is alkaline or acid must be known as well as degree of alkalinity or acidity. These properties determine whether packing materials such as flax, jute, cotton or wool can be used or whether selection must be limited to asbestos and metallic types. If the liquid is a highly concentrated acid, further limitation in the grade of asbestos used will be necessary. Decomposition of some or all of the metals used in packing manufacture can be determined from chemical properties of the liquid, which will permit us to make a further reduction in available packing possibilities.

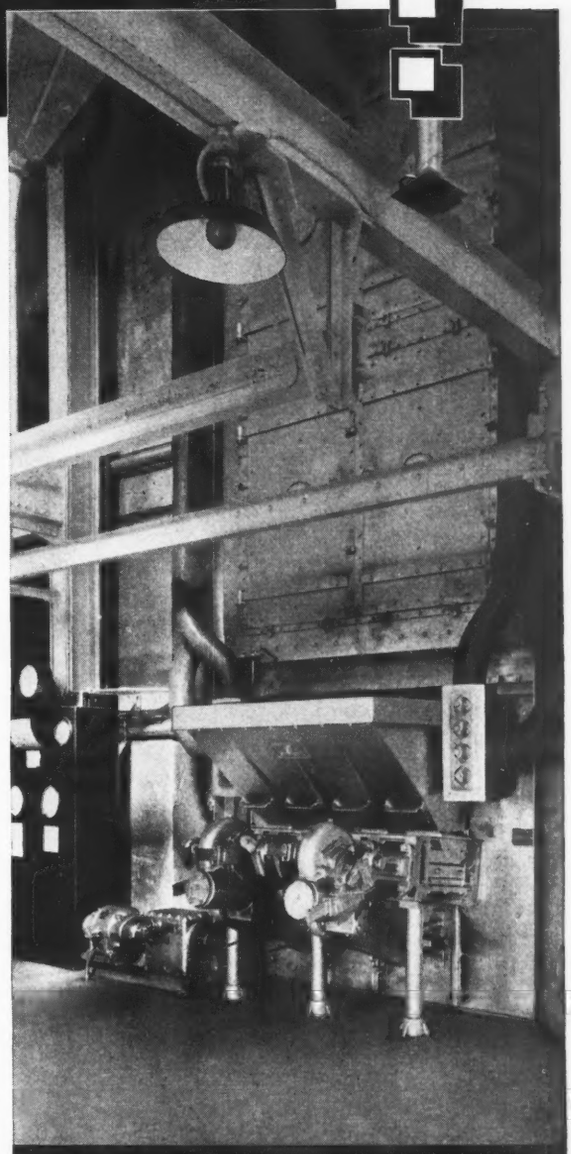
Any packing is immensely benefited if the liquid handled possesses some lubricating properties. Such liquids are not limited to those commonly accepted as lubricants in the machinery field, but to solutions that will form a film between shaft sleeve and packing. It is surprising the range of liquids that contribute acceptable lubrication in the packing box. We must, however, be on our guard, as some liquids will not wet the shaft sleeve and no lubrication is obtained no matter how oily it may appear to the touch.

Many liquids dissolve the packing lubricants and rapidly deplete them. Then, arrangements must be made to replenish the lubrication or use a metallic packing of good wearing qualities.

Operating temperature of the liquid and packing-box assembly must be considered in packing selection. If liquid temperature is high, a combination packing using one or more end rings of special composition may be required. Packing-box temperature probably will not approach that of the liquid due to radiation and possible use of a cooling chamber about the assembly. Reducing

(Continued on page 116)

How good should you expect "Feedwater Treating Service" to be?



RESULTS obtained with the feedwater treatment being used in your plant will vary with the condition of your boilers . . . the raw water supply . . . the operating rate, etc. Nevertheless, we believe you are entitled to know whether results you are obtaining are as good as should be expected.

One of the best ways to answer this question is to know about the results being obtained in other plants. Following are a few recent reports on plants served by Nalco:

NO SCALE—"They use 100% make-up of a 17 grain Lake Michigan water and operate 8 months between washouts. Boiler can be washed down to the metal. Whereas, before, heater scaled up so badly it could not be operated over one month, they now inspect it once a year and find only a very small amount of soft slush."

•

CUTS COSTS—"Mr. ———— is very well pleased with the job Nalco has done in this plant. He figures that he is saving at least $196.00 per three months per boiler, estimating fuel savings, labor savings, and reduced cost of chemical treatment."

NO TURBINING — "They have run 2 years without turbining their boilers. Their make-up is 100%. Their feed-lines and heater are absolutely clean. Their boilers, recently opened for inspection, were put back on the line immediately and without any cleaning except a quick wash."

•

ON LINE 18 MONTHS—"Yesterday the No. 4 boiler was inspected for the first time after 18 months continuous operation and was found in such good condition that it was placed back on the line, immediately. Even the lower row of tubes, which usually give evidence of a slight scale formation, were perfectly clean."

•

NALCO offers complete water treating service for power and process plants. Adoption of the Nalco System requires no additional capital investment. Total cost may be less than your present expenditures for chemicals alone.

Write for complete information. NATIONAL ALUMINATE CORPORATION, 6222 W. 66th Place, Chicago, Illinois.

THE Nalco SYSTEM OF FEEDWATER TREATMENT

Inquiries other than domestic *except those from U. S. Possessions, Canada and Mexico,* should be addressed to ALFLOC, LTD., Bush House, Aldwych, London, W. C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay St., Toronto, Ont.

temperature may widen the range of suitable packing.

Determine actual pressure on the packing. This may be affected by pump design and suction-piping size and arrangement. Practically all pump manufacturers try to reduce internal pressure on the packing so that it equals the pressure on the suction. My experience with packing problems on pumps supposed to be operating under a suction head shows that undersize suction piping, fittings and valves may cause pressure at the impeller eye to drop below atmosphere. Leakage of air inward through the packing may then occur and in some applications may cause corrosion of the equipment or contamination of product pumped. Under such conditions special packing and design may be necessary.

Packing-Box Tightness

Recently a published article on packing selection contained a statement that a completely tight packing box should be avoided and that the aim of a packing installation should be controlled leakage inasmuch as some seepage of the pumped liquid was necessary for packing-box lubrication. I cannot help but feel that the author, in making such a statement, was unconsciously limiting himself to a small group of liquids plentiful, cheap, and harmless from the corrosion and toxic standpoints. I can think of many applications in the process, chemical and refrigeration fields where leakage cannot be tolerated. Such conditions, however, may eliminate from consideration the standard types of packing and call for the use of a mechanical seal, several types of which are available.

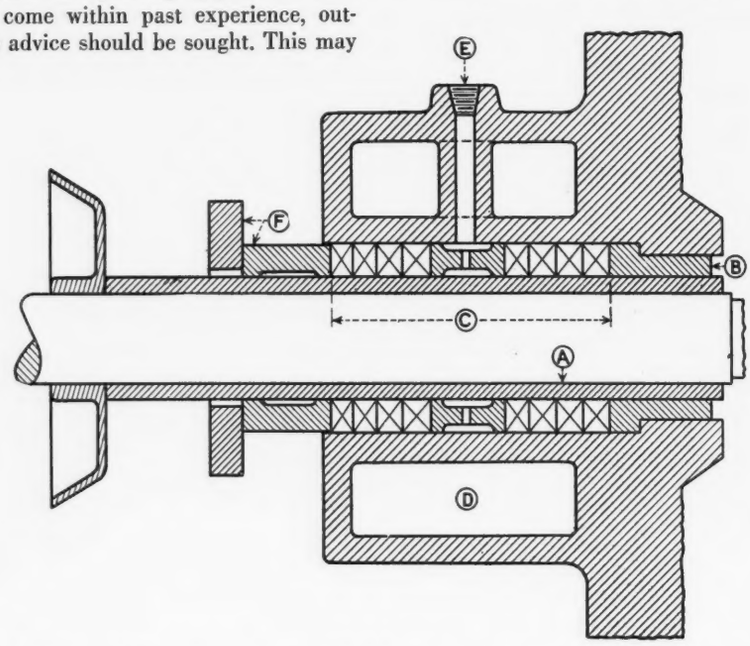
In certain cases I have used a backwash through packing to keep it free from abrasive materials in the pumped liquid. This backwash can be applied only if it will not contaminate the pumped liquid. If a suitable backwash liquid cannot be found, again use of a mechanical seal may be necessary. In such a case, however, the rubbing faces of the mechanical seal must be sufficiently hard to resist abrasion. Contamination of pumped liquid must be considered also if lubricant is to be forced into the packing box.

With the answers to these questions in front of us, it will be found that the field of packing selection has been appreciably narrowed. We are now ready to take the second step in the solution of the problem, namely, actual choice of the packing. In this, a review of past installations within one's own experience will often indicate the ultimate choice. To facilitate such a review, keep an up-to-date tabulation of all pumps in the plant or factory showing operating characteristics and conditions, type of packing and packing life, etc, on a form such as shown on page 64, March POWER.

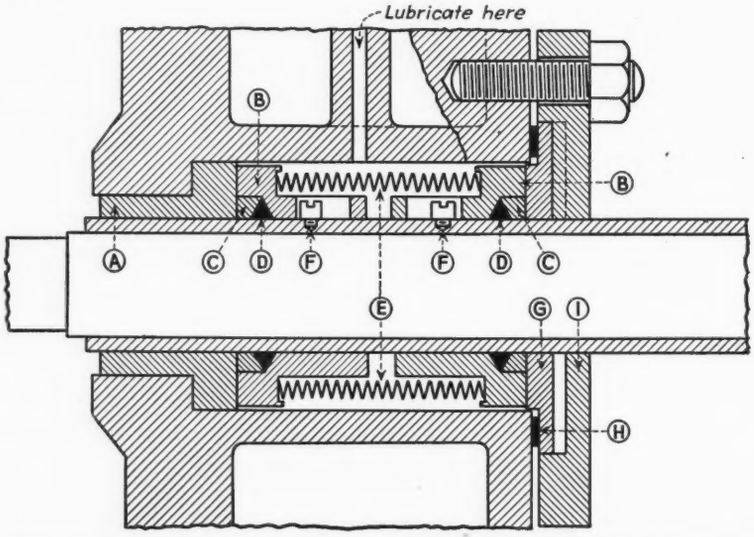
When the packing application does not come within past experience, outside advice should be sought. This may mean a study of literature and catalogs of packing manufacturers or putting the problem up to a packing manufacturer for recommendation. When doing this, give the manufacturer the complete story of pump and record of previous packing used.

New packing applications always involve some element of experimentation and frequently it will be necessary to

(Continued on page 118)



Good packing performance is aided by these points: *A*—Hardened, polished shaft sleeve. *B*—Close-fitting bushing at front end of packing box. *C*—Adequate packing length. *D*—Cooling or heating chamber around packing box when temperatures are abnormally high or low. *E*—Passage for lubrication or backwash. *F*—Close-fitting packing gland with 2-part follower



A mechanical seal may solve your packing problem. *A*—Fixed end bushing, preferably hardened. *B*—Sealing ring, rotates with shaft, free to move laterally and hardened. *C*—Hardened rotating compression ring. *D*—Rotating soft-packing ring. *E*—Rotating compression springs. *F*—Set-screws secure sealing ring to shaft sleeve. *G*—Fixed wearing plate, preferably hardened. *H*—End gasket. *I*—Gland and plate

CONTROL
IN POWER PIPING FABRICATION

Pipe bending procedure as practiced in Power Piping Division.

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Optical pyrometer control of temperatures of bending furnaces.

Power Piping Division of Blaw-Knox Company has facilities for every known type of "operations control" which may be specified under the most critical interpretation of current specifications, for use in fabricating high pressure-high temperature piping.

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Power Piping Division with its highly developed procedures and complete plant unification is in position to furnish every variety of piping regardless of size of job or pressure-temperature conditions.

A NEW BOOK

Soon ready for publication FLEX-ANAL CHARTS by E. A. Wert and S. Smith, sponsored by Power Piping Division of Blaw-Knox Co.

It is now possible for engineers using this book to figure stresses in high pressure-high temperature piping systems by means of graphs and highly simplified formulae. This book is priced at $3.00 but will be sent gratis to engineers who ask for it on their business letterheads.

BLAW-KNOX COMPANY
POWER PIPING DIVISION

1525 Pennsylvania Ave. Pittsburgh, Pa.

Getting the Right Pump Packing

(Continued from page 116)

service test two or more packings before making a final selection. When service tests are made, take care to make test conditions as uniform as possible for each packing. Frequently changes are made during a series of tests that make the data, obtained at considerable expense, valueless.

Satisfactory pump design coupled with intelligent packing selection can fail to produce good pump performance if the pump is not properly installed and packed. When the pump is installed, take every precaution to have it placed correctly on its foundation and do nothing to disturb its alignment. Make pipe connections so that no load is imposed upon the pump. This is an important point often overlooked by engineers who take great pains to insure that the piping arrangement is hydraulically correct.

Packing installation and maintenance should be handled by a careful and properly instructed mechanic. I cannot agree with the rather widely held view that any Tom, Dick or Harry with a wrench, jack-knife and packing hook is duly qualified to service pump packings. In my experience considerable packing trouble has been traced to careless jamming in of packing by a mechanic who considers the job done when the gland has been pulled up—often too tightly.

Doing the Packing Job

If conditions permit, select men for exclusive work on pump and packing maintenance. Choose them for their known ability to do careful work. Thoroughly explain the problems involved in maintenance procedures to them, and the need for painstaking work. Instill in the mechanics a sense of importance of the work by pointing out to them the vital part played by pumps in the plant or factory. Suggestions for improvements should be invited and considerately handled.

Formed rings of packing are generally more economical than packing purchased in coils, because cutting waste is eliminated. They are also more satisfactory as to fit and installation. In the interests of economy and proper packing fit, haphazard replacement of all rings in the box should be discouraged. Unless a major overhauling is being done, addition of one or two packing rings at a time should be all that is necessary. Packing in service undergoes a certain amount of conditioning which makes it superior to the new, relatively uncompressed material. The benefit of this conditioning is lost if all the rings are renewed each time the packing needs minor adjustment.

If external lubrication or some system of backwashing through the packing is used, these elements must also be carefully maintained and serviced. When mechanical seals are installed, inspect them periodically according to schedule. Frequently, such inspections will uncover minor difficulties that can be readily corrected before they develop and result in expensive repairs.

These principles and practices, although discussed with particular reference to centrifugal pumps, apply with equal force to packing on all rotating machinery and to a degree also for packing reciprocating units.

✦ ✦ ✦

Wide Speed Control on Press Power Unit

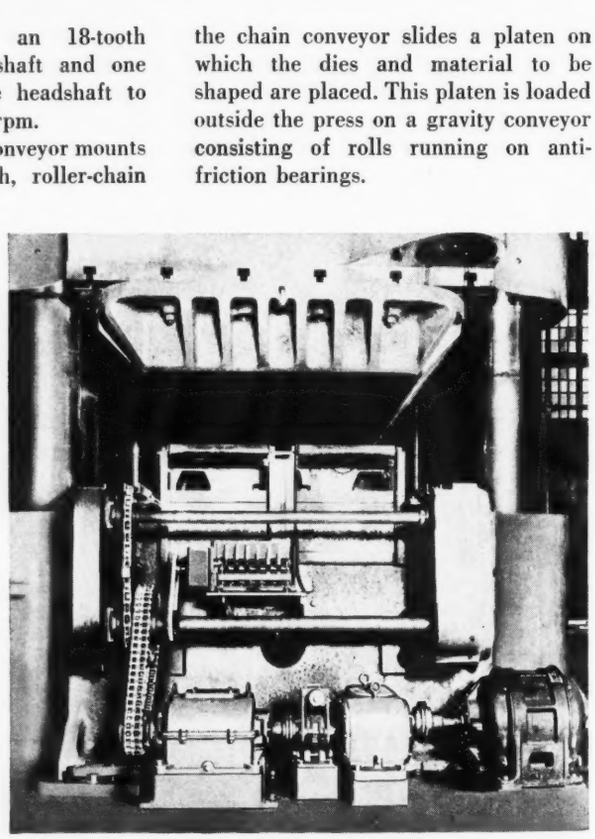
▶THE WIDE RANGE of speed adjustment required for many power applications is indicated in the photo, which shows a 5500-ton, Baldwin-Southwark hydraulic press. The conveyor is power driven by a 2-speed, constant-torque, squirrel-cage, General Electric motor, rated 5 hp at 850 rpm and 2.5 hp at 425 rpm. The motor connects through a flexible coupling to a 2-to-1 ratio, variable-speed transmission. Output speed of the transmission ranges from 1340 to 674 rpm when the motor runs high speed and 670 to 336 rpm at low motor speed. This gives an infinitely variable-speed range of 4 to 1.

Speed-Reducer Gear

The variable-speed shaft of the transmission extends for mounting a brake wheel and brake, connects through a flexible coupling to the input shaft of a double-reduction, herringbone-gear speed reducer with a rato of 29.33 to 1. Output-shaft speed of the gear can be adjusted over a range of 45.7 to 11.4 rpm. A double-width steel roller chain connects gear unit to the headshaft of the conveyor serving the press. This chain drives through an 18-tooth sprocket on the gear shaft and one having 34 teeth on the headshaft to give a speed of 24 to 6 rpm.

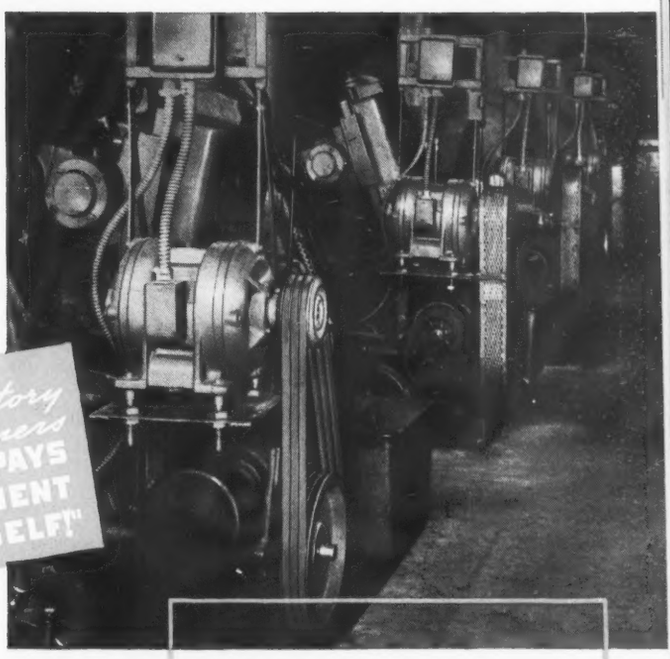
The headshaft of the conveyor mounts two 16-tooth, 2-in. pitch, roller-chain sprockets for driving the conveyor through two 2-strand roller chains 44 ft long, one on each side of the press. The variable-speed transmission, gear speed reducer and all chains are by Link-Belt Co. This equipment permits positive, infinite-adjustment of conveyor speed, by remote electrical control, to suit special operating conditions of size and characteristics of the parts being produced.

The table of the press is a stationary member over which the chain conveyor slides a platen on which the dies and material to be shaped are placed. This platen is loaded outside the press on a gravity conveyor consisting of rolls running on anti-friction bearings.



"WE'LL TAKE A CARLOAD ...OF LO-MAINTENANCE MOTORS!"

Famous Manufacturer Chooses Lo-Maintenance Motors Because of Record-Breaking Performance. Here's the Story of How You Can Protect Your Production from Motor Crack-ups . . . with Allis-Chalmers Lo-Maintenance Motors!



Another true case history from the Allis-Chalmers files that proves **"IT PAYS TO BUY THE EQUIPMENT THAT PAYS FOR ITSELF!"**

SOME OF THE 346 ALLIS-Chalmers Lo-Maintenance Motors installed in 1938 in the new Auburn, Indiana, plant of the Warner Automotive Parts Division of Borg-Warner Corporation. Equipped with Allis-Chalmers Texrope Drives for driving gear-making machines, they are in almost continuous operation . . . do not break down even when cutting tool stalls or overloads them.

WHEN YOU BUY your motors by the carload — 346 of them of the same make — you've got to have ***more*** than just confidence in the company that builds those motors. You've got to have proof . . . definite proof . . . that those motors will give you ***extra*** years of continuous service at the lowest possible cost!

That's the kind of proof Warner Automotive Parts Division of Borg-Warner Corporation wanted when they went out to buy motors for their new plant at Auburn, Indiana. So they checked motor performance in their other plants . . . got facts and figures on how motors were operating.

Here's What They Found!

They made one important discovery! In the part of their plant where conditions many times wrecked ordinary motors in short order . . . Allis-Chalmers Lo-Maintenance Motors had run perfectly for years . . . without breaking down . . . without running up expensive repair bills!

That's why they came to Allis-Chalmers for that carload order . . . standardized on Lo-Maintenance Motors in their plant! And that's why Lo-Maintenance Motors have become standard equipment in thousands of plants that want motors that give ***more*** than just a rated horsepower.

Remember, Allis-Chalmers builds Lo-Maintenance Motors with high carbon steel frame . . . indestructible rotor and distortionless stator . . . exclusive husky, all around construction with no skimping on materials — your guarantee of ***added*** protection against motor crack-ups!

By all means investigate Lo-Maintenance Motors! See how they work . . . see how they can save money in your plant! Call the nearest Allis-Chalmers district office . . . or write for Bulletin 1195.

HERE'S A TIP! When you choose new machines for your plant, ask the manufacturers to equip them with Lo-Maintenance Motors. There'll be no extra charge!

A 1188

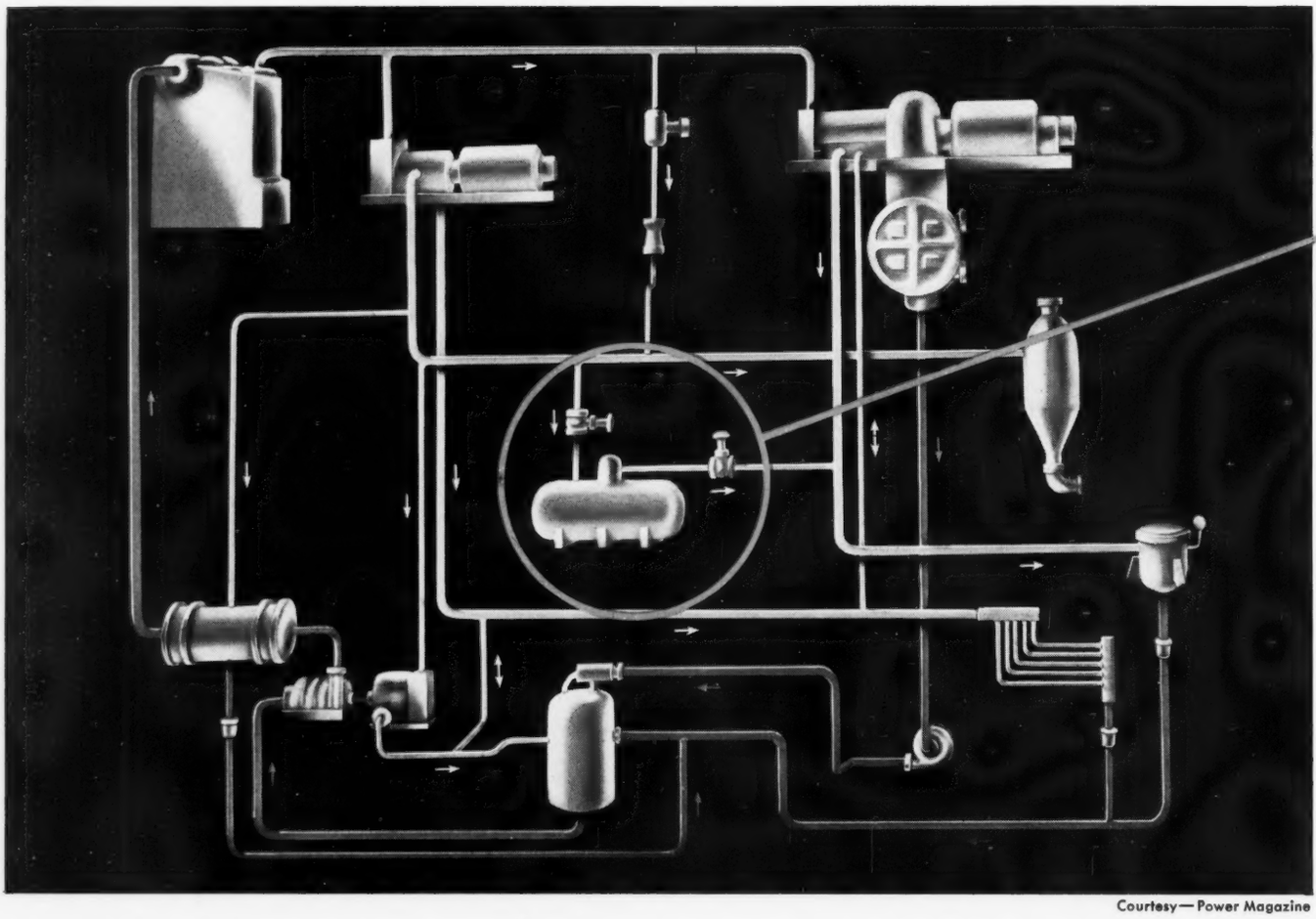
Over 90 Years of Engineering Superiority Work for You When You Specify Allis-Chalmers!

ALLIS-CHALMERS

MILWAUKEE · WISCONSIN

FROM *GOOD* POWER HOOKUPS

FOR STEAM STORAGE . . .



Courtesy—Power Magazine

HOOKUP #17 **A condensing mixed-pressure turbine and a back-pressure unit, both with extraction, supply this brewery's three process levels. Accumulator irons out swings in intermediate-pressure system at slight loss in availability of steam. High-pressure bleed line supplies accumulator, pressure in which varies widely to obtain large heat storage. Mixed-pressure turbine is designed to take in or extract l-p steam according to balance between steam and process requirements.**

IN THIS BREWERY, in fact wherever process steam demands fluctuate widely, an accumulator helps smooth out boiler load. A slight increase in boiler pressure when process demand is light, forces more steam into the accumulator, which is simply a reservoir of water ready to boil when pressure is reduced by a heavy demand in the beer kettles. Thus, accumulator pressure can float over the full range between supply and process pressures.

Perhaps we should note again that the diagrams shown in this series are not piping recommendations — but merely serve to show the basic points of control. Valves at each control point are indicated and identified with a key letter. This corresponds with the specific Figure Numbers in the table which Jenkins Engineering Advisory Service recommends for each service.

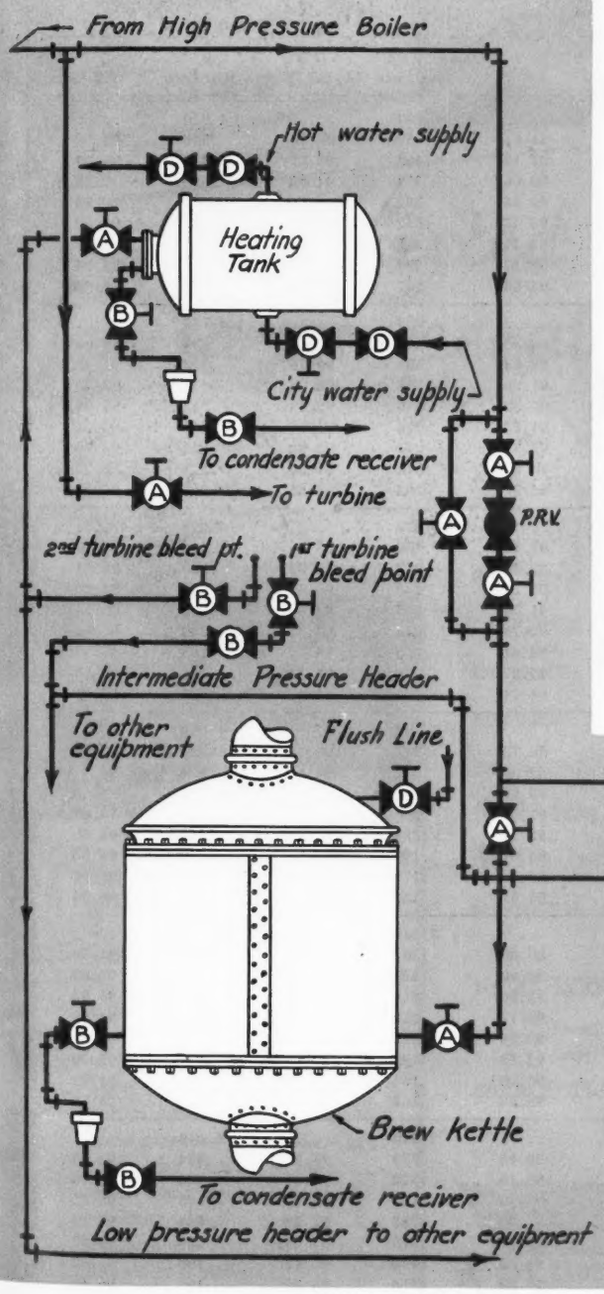
NEXT MONTH — EVAPORATOR CONNECTIONS

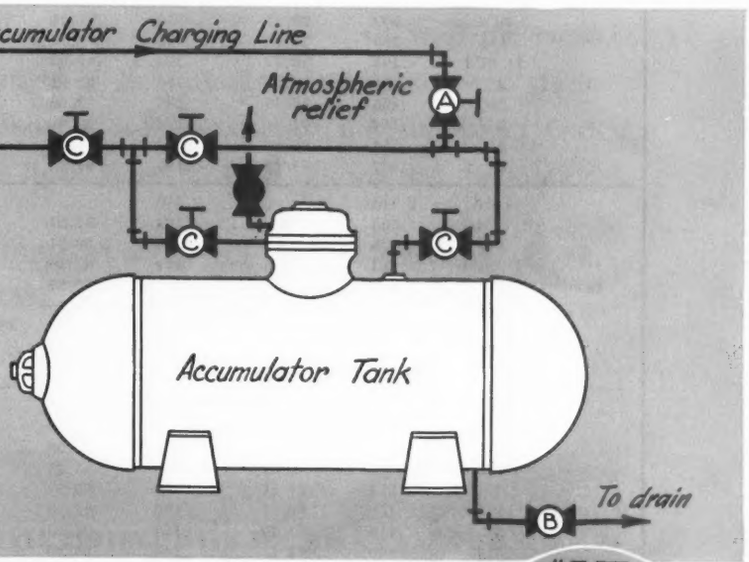
IN VALVES *Jenkins* GIVES YOU EVERYTHIN

. . . TO *GOOD* VALVE PRACTICE

Jenkins RECOMMENDS . . .

CONNECTIONS FOR ACCUMULATOR TANKS





REFERENCE CHART TO JENKINS FIGURE NUMBERS FOR STEAM STORAGE

		Standard	Medium	Extra Heavy
A	STEAM SUPPLY GATE	IRON 651 Fl. O.S. & Y.	IRON 253 Fl. O.S. & Y.	IRON 204 Fl. O.S. & Y.
	GLOBE	IRON 142 Fl. Disc Type 913 Fl. Regrinding 613 Fl. Regrinding	IRON 775 Fl. Disc Type 919 Fl. Regrinding	IRON 162 Fl. Disc Type 923 Fl. Regrinding
	ANGLE	IRON 144 Fl. Disc Type 915 Fl. Regrinding 615 Fl. Regrinding	IRON 777 Fl. Disc Type 921 Fl. Regrinding	IRON 163 Fl. Disc Type 925 Fl. Regrinding
B	DRAINS & EXHAUST GLOBE	BRONZE 106A Sc. Disc Type 750 Sc. Regrinding 950 Sc. Regr.-Renew 956 Sc. Regr.-Renew Plug IRON 141 Sc. Disc Type 142 Fl. Disc Type 912 Sc. Regrinding 913 Fl. Regrinding 612 Sc. Regrinding 613 Fl. Regrinding	BRONZE 801 Sc. Disc Type 1140 Sc. Regrinding 1150 Sc. Regr.-Renew IRON 774 Sc. Disc Type 775 Fl. Disc Type 918 Sc. Regrinding 919 Fl. Regrinding	BRONZE 970 Sc. Regr.-Renew 982 Sc. Regr.-Renew Bolt. Bonn. 976 Sc. Regr.-Renew Plug 988 Sc. Regr.-Renew Bolt. Bonn., Plug IRON 162A Sc. Disc Type 162 Fl. Disc Type 922 Sc. Regrinding 923 Fl. Regrinding
	GATE	BRONZE 47 Sc. Travel. Stem 49 Sc. Travel. Stem 370 Sc. Non-Rising IRON 325 Sc. Non-Rising 326 Fl. Non-Rising 650 Sc. O.S. & Y. 651 Fl. O.S. & Y.	BRONZE 270 Sc. Non-Rising IRON 251 Sc. Non-Rising 255 Fl. Non-Rising 277 Sc. O.S. & Y. 253 Fl. O.S. & Y.	BRONZE 280 Sc. Non-Rising IRON 203A Sc. Non-Rising 203 Fl. Non-Rising 204A Sc. O.S. & Y. 204 Fl. O.S. & Y.
C	ACCUMULATOR GATE	IRON Same as "B" above	IRON Same as "B" above	IRON Same as "B" above
	GLOBE	BRONZE 106A Sc. Disc Type	BRONZE 750 Sc. Regrinding 950 Sc. Regr.-Renew 956 Sc. Regr.-Renew Plug Type	BRONZE 801 Sc. Disc Type 1140 Sc. Regrinding 1150 Sc. Regr.-Renew 970 Sc. Regr.-Renew 976 Sc. Regr.-Renew Plug Type
	SWING CHECK	BRONZE 352 Sc. Disc Type IRON 623 Sc. Regrinding 624 Fl. Regrinding 294 Sc. Disc Type 295 Fl. Disc Type 628 Sc. Regrinding 629 Fl. Regrinding	BRONZE 762 Sc. Regrinding IRON 338 Sc. Disc Type 339 Fl. Disc Type	BRONZE 260 Sc. Disc Type 962 Sc. Regrinding IRON 338 Sc. Disc Type 339 Fl. Disc Type
D	WATER LINES GATE	BRONZE & IRON Same as "B" above	BRONZE & IRON Same as "B" above	BRONZE & IRON Same as "B" above
	SWING CHECK	BRONZE & IRON Same as "C" above	BRONZE & IRON Same as "C" above	BRONZE & IRON Same as "C" above

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#17 OF A SERIES designed to help in your selection of JENKINS VALVES

POWER'S DATA SHEETS

Number 93

Pipe-Insulation Heat Loss

▶ COMPARISON OF HEAT LOSS through various thicknesses of 85% magnesia pipe covering are given in the following table. For each pipe size and insulation thickness, heat loss is given in Btu per sq ft of *pipe* surface per hr per degree of temperature difference between pipe and surrounding air. For convenient use these are listed for temperature differences from 100 to 500 F. A second column indicates the insulation efficiency, defined as the percent saved of the loss that would have taken place from bare pipe.—*Courtesy Ehret Magnesia Mfg Co.*

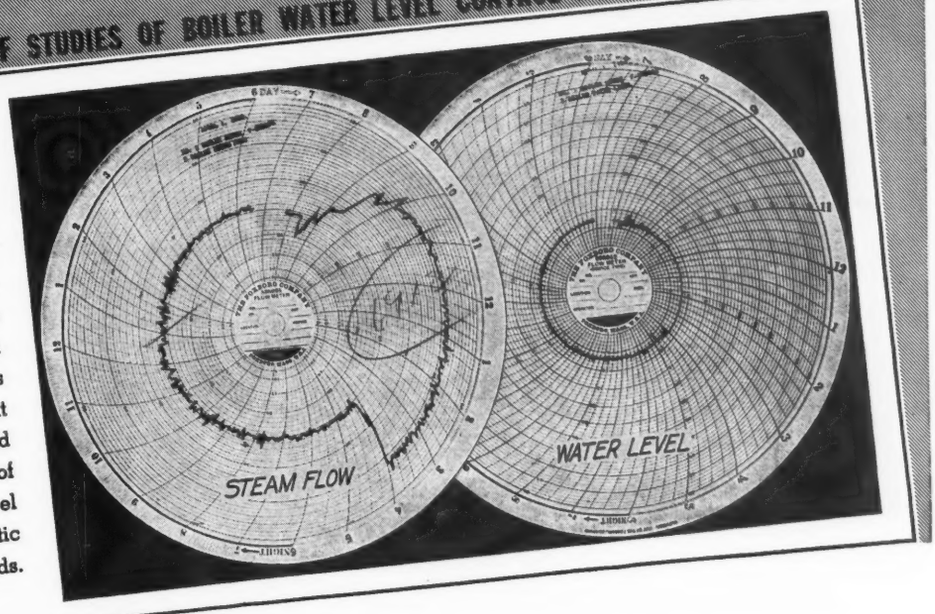
Pipe Temperature		170 F		270 F		370 F		470 F		570 F	
Temperature Difference		100 F		200 F		300 F		400 F		500 F	
Pipe Size, in.	Thickness, in.	Btu Loss	Eff %	Btu Loss	Eff %	Btu Loss	Eff %	Btu Loss	Eff %	Btu Loss	Eff %
	Bare	2.350	.....	2.850	.....	3.450	.....	4.160	.....	4.980	.....
	St'd	.471	80.00	.501	82.42	.530	84.61	.559	86.56	.590	88.96
	1½	.392	83.32	.415	85.40	.445	87.10	.463	88.87	.483	90.30
	D. St'd	.320	86.38	.335	88.25	.353	89.76	.371	91.08	.390	92.18
2	2	.337	85.66	.360	87.37	.374	89.16	.392	90.58	.408	90.80
	2½	.283	87.96	.310	89.11	.330	90.43	.342	91.77	.360	92.80
	3	.269	88.55	.282	90.10	.300	91.11	.310	92.55	.325	93.47
	3½	.246	89.50	.258	90.94	.270	92.17	.284	93.17	.297	94.04
	4	.230	90.21	.242	91.51	.254	92.63	.267	93.58	.280	94.40
	Bare	2.190	.....	2.660	.....	3.240	.....	3.950	.....	4.770	.....
	St'd	.369	83.15	.399	85.00	.431	86.39	.462	88.75	.495	89.62
	1½	.332	84.84	.350	86.84	.370	88.58	.386	90.70	.408	91.45
	D. St'd	.255	88.36	.269	89.89	.283	91.26	.297	92.93	.311	93.48
4	2	.276	87.39	.290	89.09	.304	90.62	.318	92.39	.331	93.06
	2½	.235	89.27	.248	90.67	.263	91.88	.274	93.07	.285	94.48
	3	.206	90.59	.218	91.81	.230	92.90	.241	93.90	.253	94.70
	3½	.190	91.32	.199	92.44	.207	93.61	.216	94.50	.228	95.22
	4	.175	92.01	.184	93.09	.194	94.01	.203	95.34	.213	95.53
	Bare	2.130	.....	2.590	.....	3.180	.....	3.890	.....	4.690	.....
	St'd	.348	83.67	.376	85.49	.403	87.32	.430	88.95	.460	90.19
	1½	.302	85.82	.314	87.88	.335	89.46	.353	90.93	.370	92.11
	D. St'd	.224	89.49	.236	90.89	.248	92.20	.260	93.32	.272	94.20
6	2	.243	88.59	.258	90.04	.270	91.50	.285	92.67	.295	93.71
	2½	.205	90.37	.218	91.58	.230	92.76	.240	93.83	.252	94.62
	3	.182	91.46	.192	92.59	.203	93.61	.215	94.47	.225	95.20
	3½	.166	92.20	.174	93.27	.182	94.27	.190	95.11	.198	96.78
	4	.150	92.96	.158	93.90	.167	94.74	.176	95.47	.185	95.08
	Bare	2.090	.....	2.560	.....	3.140	.....	3.860	.....	4.660	.....
	St'd	.309	85.22	.330	87.11	.354	88.72	.377	90.23	.399	91.44
	1½	.288	86.22	.301	88.24	.324	89.68	.342	91.14	.354	92.41
	D. St'd	.193	90.77	.205	92.00	.217	93.08	.228	94.10	.240	94.85
8	2	.230	89.00	.240	90.62	.255	91.87	.266	93.11	.280	94.00
	2½	.193	90.76	.205	92.00	.217	92.77	.228	94.09	.240	94.85
	3	.169	91.91	.178	93.05	.188	94.01	.199	94.85	.210	95.50
	3½	.154	92.63	.162	93.67	.170	94.58	.179	95.36	.188	95.97
	4	.137	93.44	.145	94.33	.154	95.12	.162	95.81	.169	96.37
	Bare	2.070	.....	2.540	.....	3.120	.....	3.840	.....	4.640	.....
	St'd	.303	85.36	.323	87.29	.343	89.00	.364	90.52	.385	91.70
	1½	.275	86.71	.292	88.51	.312	90.00	.326	91.51	.342	92.63
	D. St'd	.183	91.16	.194	92.36	.207	93.36	.218	94.32	.231	95.02
10	2	.220	89.37	.232	90.87	.244	92.11	.256	93.33	.269	94.20
	2½	.183	91.16	.194	92.36	.207	93.36	.218	94.32	.231	95.02
	3	.160	92.27	.170	93.31	.180	94.23	.190	95.05	.200	95.70
	3½	.144	93.04	.150	94.09	.156	95.00	.164	95.73	.172	96.29
	4	.128	93.81	.136	94.65	.144	95.38	.152	96.04	.159	96.58
	Bare	2.050	.....	2.520	.....	3.100	.....	3.810	.....	4.610	.....
	St'd	.270	86.83	.285	88.69	.305	90.16	.320	91.66	.334	92.76
	1½	.270	86.83	.285	88.69	.305	90.16	.320	91.66	.334	92.76
	D. St'd	.156	92.39	.166	93.43	.176	94.32	.186	95.12	.193	95.82
12	2	.215	89.51	.228	90.95	.239	92.30	.252	93.39	.264	94.27
	2½	.180	91.21	.192	92.38	.204	93.42	.215	94.35	.226	95.27
	3	.156	92.39	.166	93.43	.176	94.32	.186	95.12	.193	95.82
	3½	.140	93.17	.146	94.20	.152	95.09	.158	95.85	.165	96.42
	4	.125	93.90	.134	94.70	.142	95.42	.150	96.07	.155	96.64

© POWER

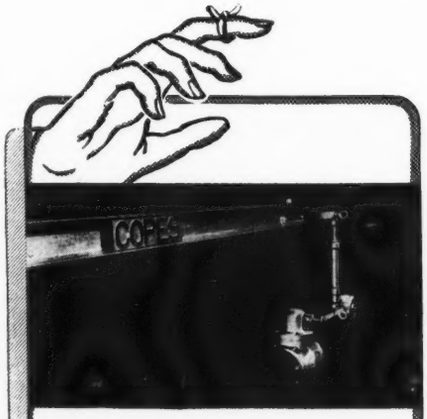
NO. 3 IN A SERIES OF STUDIES OF BOILER WATER LEVEL CONTROL WITH COPES FLOWMATIC

600 POUNDS W. S. P.

Firing with acid sludge or gas normal evaporation is as high as 350,000 lb. per hr. on this 600-lb. pressure Riley Steam Generator. Water level is carried one inch higher at 360,000 lb. per hr. peak load than at normal minimum of 242,000 lb. per hr. Level control by COPES Flowmatic is unusually close on all loads.



★ *Unaffected by drafts or changes in temperature—even outdoors*



If simple level control is adequate for your boilers, specify the COPES Type BI Regulator—the most modern design of the original continuous-feed regulator. Working directly from your boiler water level, with a minimum of working parts, it assures safer operation of boilers carrying moderate pressures and swings in load, and builds efficiency. Gives good results, indoors or outdoors, despite changes in temperature. Write for COPES Regulator Catalog.

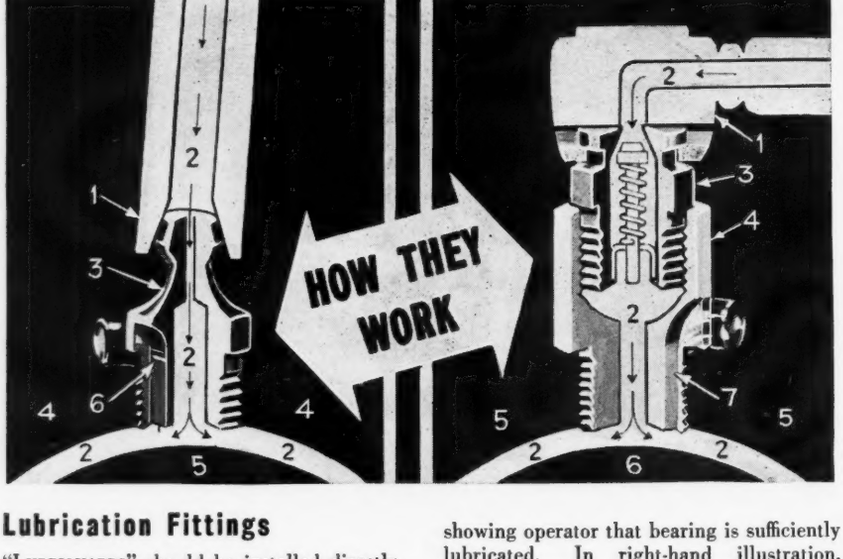
Experience shows that changes in atmospheric temperature have no effect on the dependably accurate performance of the COPES Flowmatic Regulator. This installation, for example, is all outdoors and temperature changes of 80 degrees F. have not interfered with correct feed regulation or water level control. Nor has there been need for factory service. This Flowmatic, cut into service and accurately adjusted by plant personnel, has worked well for more than two years with only routine inspection and care. Write for Bulletin 409-B describing the simplified two-element steam-flow type COPES Flowmatic Regulator.

NORTHERN EQUIPMENT CO., 401 GROVE DRIVE, ERIE, PA.

Feed Water Regulators, Pump Governors, Differential Valves
Liquid Level Controls, Reducing Valves and Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY AND ITALY
REPRESENTATIVES EVERYWHERE

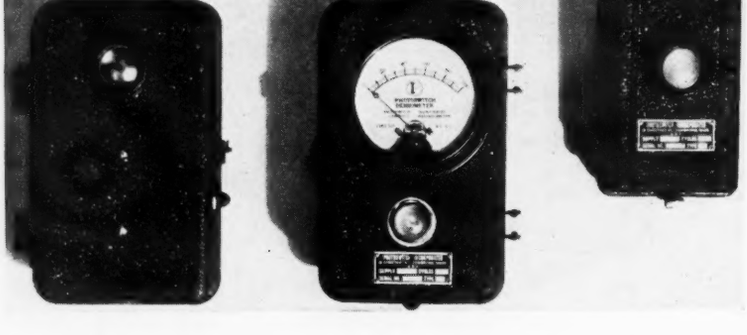
★ GET CLOSER LEVEL CONTROL WITH THE COPES FEEDS BOILER ACCORDING TO STEAM FLOW AUTOMATICALLY FLOWMATIC ★ REGULATOR



Lubrication Fittings

"LUBRIGUARDS" should be installed directly into bearing, as shown in illustration, left. In operation, hydraulic-type pressure gun (1), is applied to fitting, (2). Lubricant is forced through inlet of hydraulic fitting (3), installed on bearing housing, (4), into the anti-friction bearing, (5). When a predetermined amount of backpressure is developed in the bearing, excess lubricant appears at vent (6), showing operator that bearing is sufficiently lubricated. In right-hand illustration, bushing, (4), enables bearings equipped with button-head dot, pin-type and other conventional-type bushings to receive Lubriguard protection. (1) is pressure gun, (2) lubricant, (3) fitting, (4) bushing, (5) bearing housing, (6) bearing, and (7) excess lubricant vent.

Alemite Div, Stewart-Warner Corp, 1826-1852 Diversey Parkway, Chicago, Ill.



Smoke Alarm

ELECTRIC EYE smoke alarm with densometer makes photoelectric control of combustion conditions available to power plants at smaller cost, according to maker. In illustration, (left to right), alarm consists of photoelectric control, densometer-signal combination, and light source. Light source and photoelectric control are mounted on opposite sides of the flue or breeching, and are aligned through tubes or windows so that beam projected from light source strikes eye of control. When smoke density exceeds certain limits, unit will flash red lamp, but normal density will register on densometer dial.

Photoswitch, Inc, 21 Chestnut St, Cambridge, Mass.

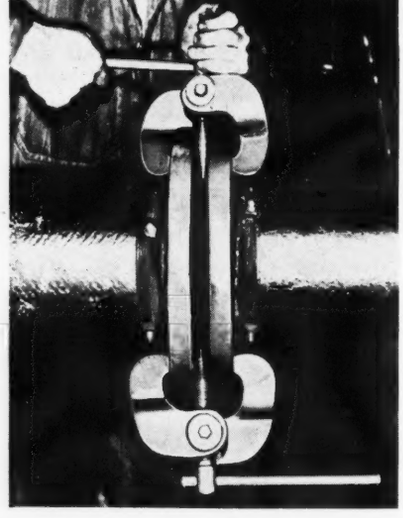
Circuit Breaker

TYPE KB circuit breaker is new model of Type K breaker, with several improvements. Is 3-pole, 600-amp unit mounted in individual pull-box steel enclosure. Interrupting ability of new unit is such that in dust-proof chamber it can be rated at 20,000 rms. Mechanical closing arrangement may be operated without internal change either by handle or solenoid. Direct-acting overcurrent trip is obtained through the use of a trip-coil, which carries all of the current in the circuit and operates the tripping mechanism at the required setting.

I T E Circuit Breaker Co, 19th & Hamilton Sts, Philadelphia, Pa.

Gasket Tool

FLANGE-JACKS are designed specifically to open flanges on pipelines for renewal of gaskets. In operation, two bolts are removed from flanges opposite each other. Jaws of the jacks are placed in each bolt hole and tightened enough to hold jacks in position. Remainder of bolts are then



removed from joint. Jackscrews are tightened at the same time to separate flanges evenly, with lubrication being applied freely at points and screws. When sufficient opening has been reached, old gasket is removed and, after flange faces are cleaned, new gasket is inserted. Jackscrews are then backed off simultaneously, jacks are removed and bolts applied.

Garlock Packing Co, Palmyra, N. Y.

Variable-Pitch Fans

SAID TO SHOW fuel economies of more than 10%, variable-pitch fans on some types of internal-combustion engines operate on principle of maintaining most efficient engine operating-temperature under all load and weather conditions. Thermostat on air or water jackets causes variable-pitch fan-blades to move into correct position for necessary air movement to reach this temperature, which is then automatically maintained. When cooling is not required, further economy is said to be effected, be-

(Continued on page 144)

The Case of the DEADLY THIRST

SOLVED WITH PREVENTIVE MAINTENANCE

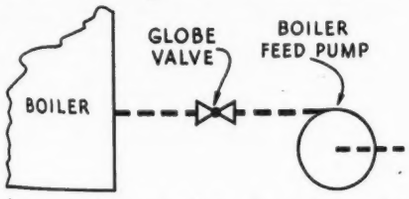
"Killing that boiler will cost us real money," shouted the SUPERINTENDENT. "We can't keep up with orders now!"

"It might have been lots worse," sighed the PLANT ENGINEER," . . . if we hadn't located the trouble in time."

"But, it won't happen again," said the CRANE MAN," . . . now that you've applied Preventive Maintenance with the right Crane valve."

THE machinery in a manufacturing plant in the Middle West was humming gaily to the tune of big orders and lots of them. But, suddenly, one day the hum quieted considerably. One of the high pressure boilers had to be "killed." A valve in the feed water line jammed; the fire had to be pulled or the thirsty boiler would burst.

The valve was a gate with rising stem and solid wedge disc. Throttling service and the pulsating flow from the feed water pump were more than the valve could stand. Constant vibration of the disc cut the stem in two. The disc dropped, and seating itself, tightly shut off the water line.



To make repairs by the rule of ordinary maintenance would be folly. Only a valve that would prevent recurrence of such trouble would do. And that's how Preventive Maintenance—recommended by G. L. C., the Crane Representative—came into the case.

For two sound reasons Preventive Maintenance prescribed a globe valve with plug type disc. *First,* it could be installed with pressure under the disc; and should the valve fail, it would not stop water supply to the boiler entirely. *Second,* its plug type disc and seat construction would offer maximum resistance to the severity of throttling service.

Results: (1) the trouble was quickly remedied. (2) The threat of another costly boiler shutdown due to misapplied valves was removed. (3) Another manufacturer has learned that Preventive Maintenance is sound economy; and that Crane offers not only the most complete and dependable source of valves and fittings, but accurate information on application as well. He knows, too, the wisdom of consulting the Crane Salesman on every piping problem—big or little.

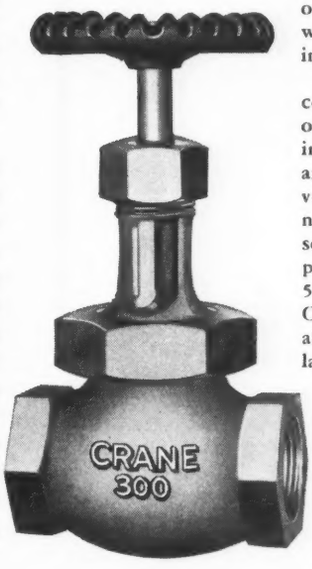
This case is based on an actual experience of a Crane Representative in our Oshkosh Branch.

CRANE BRASS PLUG DISC VALVES TAME POWER PLANT FLOW

In your boiler room—in lines where the service is really tough, you'll find these valves exactly right for the job to be done, right for the safety required. Use them for throttling, in soot blower, blow off, boiler feed, in drip and drain lines.

Crane brass plug type disc globe valves are extra strong and durable; they're made of a high-grade steam metal. Their wide seating area is designed to resist the damaging effects of wire drawing and foreign matter. The disc taper assures tightness; permits easy regulation of flow.

Their discs of nickel-alloy and seats of exelloy are a tough combination that gives stubborn opposition to wear, wire drawing and galling.



Available in complete range of pressure ratings, these valves are ideal for Preventive Maintenance in a lot of services. For 300 pounds steam at 550°, ask your Crane Salesman about the popular No. 382 P.

1940 OUR 85th YEAR

CRANE

CRANE CO., GENERAL OFFICES
836 S. MICHIGAN AVE., CHICAGO

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

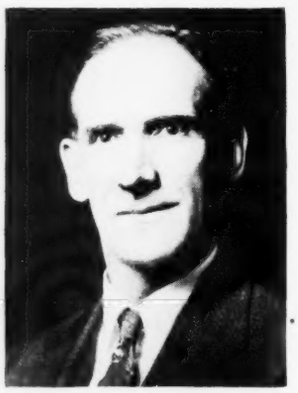
Power Lines

Nineteen Engineers and Scientists Honored As "National Pioneers" at National Banquet

In a series of regional dinners, climaxed by the great national banquet at New York's Waldorf-Astoria Hotel on February 27, the National Association of Manufacturers celebrated the 150th anniversary of the American patent system and paid dramatic tribute to America's "Modern Pioneers", the men who have contributed most effectively through science and invention to the miracle of modern civilization. In all, 572 engineers and scientists were so honored, and, of these, 19 were designated National Modern Pioneers for outstanding achievements. Several of the nineteen have worked in, or parallel with, the power field. Notable examples are Carrier, Cottrell, Kettering and Langmuir.

In the larger group of 572 are many names associated with power production or with leading manufacturers of power equipment.

While the National Association of Manufacturers arranged the dinners and broadcasts, presented the silver plaques to the 19 national pioneers, and scrolls to the others, the actual selection of men to be honored was left in the hands of a distinguished committee well removed from any suggestion of commercial pressure. Nominations were made by the National Modern Pioneers Committee of 80 distinguished industrialists headed by Robert L Lund, but the final choice was made by the Committee on Modern Pioneer Awards: President Carl T Compton (chairman) M I T; Dean John T Pate of the University of Minnesota; permanent secretary Forest R Moulton of the American Association for the Advancement of Science; Director Edward R Weidlein of Mellon Institute; Dean George E Pegrann of Columbia; and Dean Frank C Whitmore of Penn State.



Cottrell electrified dust and gave his invention away

Among the 19 National Modern Pioneers were Henry Ford (a former operating engineer) and four others whose inventions have served the power field: Willis H Carrier, air-conditioning pioneer, Frederick G Cottrell, inventor of Cottrell Process for the electrical precipitation of dust; Charles F Kettering, General Motors, inventor of the self-starter and portable lighting units, and a leader in diesel-engine improvements; and Irving Langmuir, General Electric's outstanding physicist, whose improved incandescent lamp saves millions of dollars in power bills.

Others of the 19 were Edwin H Armstrong, radio broadcasting pioneer, Leo H Baekelind, inventor of Velox photographic paper and of Bakelite; William M Burton, pioneer in the cracking process for gasoline; George C Curme, Jr, Carbide & Chemical Corp, who founded a whole new chemical industry; Lee de Forest, inventor of the electron tube; John Van Nostrand Dorr, inventor of the revolutionary methods of handling and treating materials; Edwin H Land, inventor of Polaroid.

Harry Steenbock, inventor of new food products: John B Tytus (American Rolling Mill Co) the man behind the continuous rolling process for steel; Charles F Wallace, (Wallace & Tiernan Co) inventor

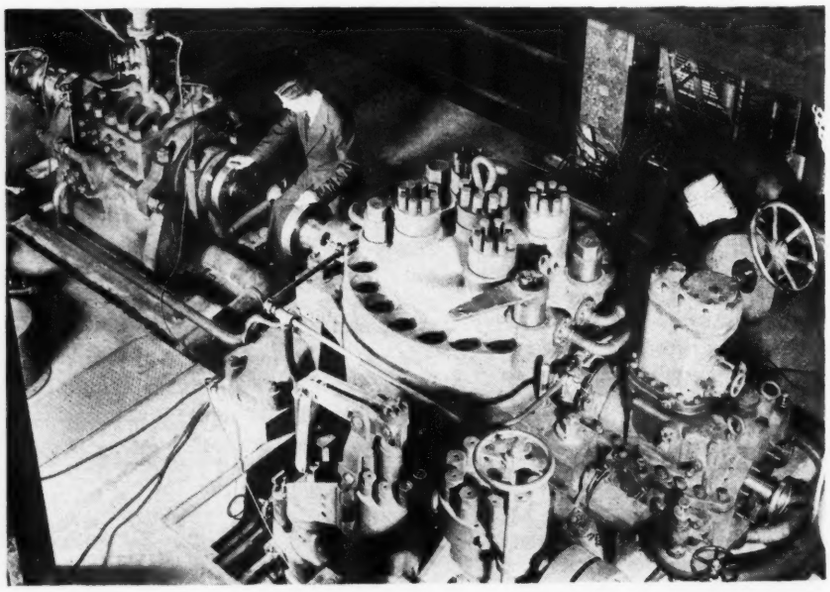
Carrier made the power engineer a weather-control man

MOUNTAIN MEETS MOHAMMED MIDWAY

Engineers of the Westinghouse South Philadelphia Works do not have a quarter-million lb per hr of 1200-lb, 900-F steam in their backyard, so a cooperative arrangement with Philadelphia Electric Co's Schuylkill Station permits test of first-row turbine-blade vibration. Two-wheel, 10,000-kw turbine in foreground has a hollow shaft, visible at lower right, through which an optical system indicates or records the actual motion of a blade as it is struck by a high-pressure steam jet.

The turbine is connected to a 15,000-hp water brake capable of absorbing the entire turbine output when required. Water brake allows testing under load at different speeds as speed variation as small as 1½% can bring blade into resonance and increase vibration amplitude three or four times. For long-time tests, a 10,000-kw generator with a new type of flexible foundation will feed the power output into the Philadelphia Electric System.

Preliminary results on a small turbine operating at low pressure in the Westinghouse shops show that resonance vibration at the natural frequency of the blade can be extremely severe under conditions of partial peripheral admission of steam. Metals usually fail from fatigue after about 10 million cycles under such stress and a turbine blade may be called on for 200 million cycles in a single day. The experimental work will aid in selecting the best of several blade designs and shroud arrangements.



CONFUCIUS SAY:

"Man Who Buy Boilers Before Investigating Water MAKE PROGRESS BACKWARD"

Since your local water is the raw material from which you will make all your steam—it is obvious that you should engage your water consultants *before* you ask for bids on new boilers.

Working for your ultimate satisfaction, these consultants will furnish exact water specifications upon which all boiler manufacturers may bid on an equal basis — eliminating installation headaches and the huge expense of many changes so frequently necessary to adapt new boilers to unexpected water difficulties.

W. H. & L. D. Betz, Chemical Engineers and Consultants on *all* water problems —a strictly professional organization with no equipment to sell—render this valuable service to the leaders of Industry, save much trouble and expense *before it happens.*

An inquiry will not obligate you in any way.

W. H. & L. D. BETZ, 235 W. Wyoming Avenue, Philadelphia

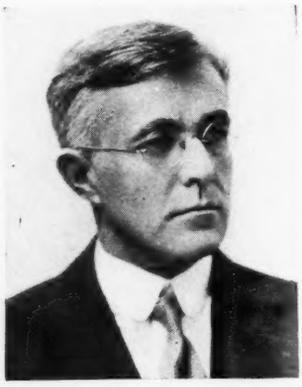
Branch Offices at: 50 CHURCH STREET, NEW YORK • 37 W. VAN BUREN STREET, CHICAGO
WOOD INDUSTRIES, LTD., ROYAL BANK BUILDING, MONTREAL, QUEBEC, CANADA

Chemical Engineers Strategically Located

CONSULTATION • PLANT STUDIES • **BETZ** PLANT DESIGN • SERVICE SUPERVISION

Chemical Engineers and Consultants on All Water Problems

of numerous devices for measuring and controlling flow of fluids, pioneer in the application of liquid chlorine in water treatment; Orville Wright, co-builder with his brother Wilbur, of the first power-



Langmuir put gas in a lamp, saved millions of dollars

driven heavier-than-air flying machine; Vladimir K Zworykin (RCA Mfg Co) pioneer in sensitive photo cells and television sets.

Among the regional Modern Pioneers honored were the following, associated with the power field, directly or through the manufacture of power equipment:

NEW YORK AREA:

John C Baker
Wallace & Tiernan Co

Frederick M Becket
Union Carbide & Chemical Corp

William David Coolidge
General Electric Co

Garland Hale Barr Davis
Standard Oil Development Co

Gano Dunn
J G White Engrg Corp

George Herbert Gibson
Montclair, N. J.

William Nelson Goodwin, Jr.
Weston Electrical Instrument Corp

Claude J Holslag
Electric Arc Cutting & Welding Co

David Schenck Jacobus
Babcock & Wilcox Co

Albert Kingsbury
Kingsbury Machine Works, Inc

John Kirgan
Elizabeth, N. J.

Irving Langmuir
General Electric Co

Henry W Pleister
Diamond Expansion Bolt Co

Max Spillman
Worthington Pump & Machinery Corp

Charles Frederick Wallace
Wallace & Tiernan Co, Inc

Willis R Whitney
General Electric Co

John Francis Grace
Thomas Canning McBride
Worthington Pump & Machinery Corp

George Dolan
Public Service Electric & Gas Co
Harry B Smith, United Engineers

(Continued on page 162)

NEW PLANT CONSTRUCTION

McGraw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service

California—Bureau Reclamation, Wash., D. C., plans irrigation, flood control and power improvements, incl. constructing Pine Flat Dam, 15,000 kw. power plant and transmission lines. $22,500,000.

Calif., Rio Vista—Spreckels Sugar Co., 2 Pine St., San Francisco, plans constructing beet sugar processing plant, 1,500 to 2,000 tons per day cap. $1,500,000-$2,000,000. Private plans by Owner's Engineering Dpt.

Calif., San Diego—Consolidated Aircraft Co., 3302 Pacific Hy., plans constructing airplane factory, asphaltic concrete paving yards, etc. $1,500,000.

Fla., Marathon—Monroe County Rural Electrification Assn., c/o J. A. Russell, Islamorada, pres., plans constructing power plant and 110 mi. electric wires. $200,000. E. B. McLean, c/o owner, engr.

Fla., Orlando—Orlando Utilities Comn., S. Y. Way, mayor, City Hall, plans by Associated Orlando Architects, 6 W. Church St., constructing 2 sub-stations for municipally-owned power plant. $195,000. M. W. Brown, Orlando Utilities Comn., Wall and Main Sts., engr.

Ill., Belleville — St. Clair Co., c/o Bd. Supervs., plans constructing coal processing plant to produce smokeless fuel for St. Louis, Mo., market, vicinity of here. $6,500,000.

Ill., East Moline — International Harvester Co., E. W. Stahl, plant supt., 180 N. Michigan Ave., Chicago, Ill., soon takes bids 393x770 ft. manufacturing building $1,000,000, and office building containing 24,000 sq. ft. space.

Ill., Joliet—Pub. Serv. Co. of Northern Illinois, Joliet, making plans constructing steel power plant. $750,000. Sargent & Lundy, 140 S. Dearborn St., Chicago, engrs.

Ind., Frankfort—Bd. P. Wks., W. P. Lockwood, mayor, City Hall, making sketches constructing power plant, 6,000 to 7,000 kw. generator, $300,000. Froehlich & Emery Eng. Co., 2nd Natl. Bank Bldg., Toledo, O., consult. engrs.

Ia., Calmar—City contemplates advertising for bids about Apr. 15, constructing light plant and equipment. $45,000. Hubbard Eng. Co., 415 N. LaSalle St., Chicago, Ill., engrs.

Ia., Cedar Falls—Bids April 16, by City, constructing hydro-electric power plant on Cedar River. $185,000. C. H Streeter, city engr.

Ia., Lone Tree—H. A. McMillan, town clk., plans constructing electric light plant.

Ia., Oelwein—J. B. Henderson, mayor, will start taking bids about Mar. 20, constructing light plant. $45,000. Hubbard Eng. Co., 415 N. LaSalle St., Chicago, Ill., engrs.

Kan., Abilene—Kansas Power & Light Co., Abilene, plans constructing light and power plant and equipment, accessories. $1,750,000.

Ky., Louisville — Louisville Gas & Electric Co., 311 W. Chestnut St., plans constructing plant improvements. $2,015,615. L. W. Pickel, 311 W. Chestnut St., engr. in charge of Special Constr. Dpt.

Ky., Louisville — Louisville Gas & Electric Co., 311 W. Chestnut St., will construct addition to Canal Station, 25,000 kw. capacity, installing new generator, new boiler, pumps and accessories, by own forces. $2,300,000. L. W. Pickel, 311 W. Chestnut St., engr. in charge of Special Constr. Dpt.

Mass., Spencer—Town, Bd. Selectmen, Town Hall, plans constructing brick, steel power plant. $40,000.

Mo., Brookfield — Missouri Power & Light Co., Brookfield, plans installing new 5,000 kw. generating unit and auxiliaries, etc. $500,000.

N. J., Belleville—Bids Mar. 20, by Andrew Jergens Co., 2535 Spring Grove Ave., Cincinnati, O., constructing pharmaceutical plant and boiler house, Mill St. $1,000,000. Tietig & Lee, 34 W. 6 St., Cincinnati, O., archts. A. M. Kinney, Inc., 1820 Carew Tower, 5 and Vine Sts., Cincinnati, O., engrs.

N. Y., Binghamton—Bids Apr. 10, by State, Dpt. Mental Hygiene, State Bldg., Albany, constructing power plant at State Hospital. $810,000. W. E. Haugaard, State Bldg., Albany, archt.

N. Y., Buffalo—Washburne Crosby Co., W. R. Morris, pres., div. General Mills, Inc., Marine Trust Bldg., plans reconstructing cereal plant, Michigan Ave. Over $500,000. H. W. Crosby, ch. engr., c/o owner, and Chamber of Commerce Bldg., Minneapolis, Minn.

N. Y., Herkimer — Municipal Comn. plans constructing municipal power plant improvements. Gibbs & Hill, Pennsylvania Sta. Bldg., New York, engrs. Recommendations not yet made.

N. Y., Jamestown—Jamestown Metal Equip. Co., Inc., O. A. Lenna, pres. and mgr., 1088 Allen St., bids in spring or early summer, 1 story, 240x700 ft., brick, steel factory, to house Blackstone Washing Machine Div. of owners. $250,000-$300,000. E. B. Card, c/o owner, ch. engr.

N. Y., New York—Standard Oil Co. of New Jersey, 30 Rockefeller Plaza, plans constructing plant for manufacture of synthetic rubber. $1,000,000-$1,250,000. Site not selected.

N. Y., Oswego—Central New York Power Corp., Electric Bldg., Buffalo, plans further expansion of steam generating plant. Over $10,000,000. N. R. Gibson, Electric Bldg., Buffalo, engrs.

O., Galion—City takes bids in about 60 days, installing new boiler and auxiliaries at light plant. $90,000. J. F. Nichols, service dir.

O., Mt. Gilead—Hydraulic Press Mfg. Co., H. F. MacMillen, pres., plans constructing new modern manufacturing plant on 60 acre site. $500,000. Private plans.

O., Painesville—Industrial Rayon Corp., H. S. Rivitz, pres., W. 98 St. and Walford Ave., Cleveland, sketches by Wilbur Watson & Assoc., 4614 Prospect Ave., Cleveland, constructing 1 and 2 story, brick, steel, concrete building, doubling present plant for manufacture rayon silk. Total est. $2,000,000.

O., Toledo—Panda Oil & Refinery Co., 1201 Oakwood Ave., G. Thomas, pres., plans general development and enlargement program, refinery plant addition on Congress St., capacity increased from 150,000 gal. gasoline to 500,000 gal. $500,000. Private plans.

O., Toledo—Toledo Edison Co., Edison Bldg., C. L. Proctor, vice pres. and genl. mgr., plans expansion program, incl. installing 50,000 kw. turbo-generator units and 2 boilers of 900 lb. pressure at Acme power plant, etc. $5,250,000.

O., Youngstown—United Eng. & Fdry. Co., 219 Phelps St., plans expansion plants, constructing 1 story, modern, brick, steel office building, improving and enlarging present building. $1,000,000. Private plans.

Ore., Portland—Pacific Power & Light Co., Pub. Serv. Bldg., plans power plant improvements during year 1940. $1,000,000. H. H. Schoolfield, genl. supt. in charge construction.

Pa., Marcus Hook—American Viscose Corp., Marcus Hook, plans constructing rayon plant somewhere in southeastern section of U. S. $5,000,000. Private plans. Site to be selected soon.

Pa., Sharon—Pennsylvania Power Co., W. H. Sammis, pres., 19 E. Washington St., New Castle, plans general expansion and improving facilities in new distribution lines, extensions, sub-station improvements, etc., in Sharon and Mercer Co. $1,000,000. G. Daniels, 212 W. Michigan Ave., Jackson, Mich., engr.

S. C., Branchville—Orangeburg-Aiken Hydro-electric Comn., J. M. Green, chn., Orangeburg, plans constructing hydro-electric project, Edisto River, near here. $1,000,000.

Tenn., Nashville—Nashville Coal Co., Stahlman Bldg., plans constructing coal carbonizing plant. Over $500,000. E. Wilson, in charge, c/o owner.

Tex., Beaumont — Socony-Vacuum Oil Co., 230 Park Ave., New York, N. Y., and Magnolia Petroleum Co., Beaumont, will construct reforming and thermal polymerization unit in refinery area outside city limits, by force account. $750,000 incl. equip.

Tex., Dallas — Proctor & Gamble, Inc., Gwynne Bldg., Cincinnati, O., and 1226 Lommis St., Dallas, plans constructing soap manufacturing plant. $1,000,000.

Tex., Texas City—Pan-American Refining Corp., c/o D. J. Smith, vice pres., 122 E. 42 St., New York, N. Y., receiving bids constructing grease manufacturing plant. $1,000,000. 160 acres land purchased.

Tex., Waco—Owens-Illinois Glass Co., Ohio Bldg., Toledo, O., and Alton, Ill., takes bids early in summer, constructing 3 buildings and equipment. About $600,000. R. A. Cosh, c/o General Eng. Dpt. of Co., Alton, Ill., designing engr. E. W. McVeigh, Alton, Ill., constr. engr.

Washington—Puget Sound Power & Light Co., 7 and Olive Sts., Seattle, plans constructing transmission and distribution lines, substation, meters, transformers, etc. $1,812,564, bus properties $315,864, general structures, equipment, tools $115,702, power plants $182,978. Total $2,500,000.

Wash., Vancouver—Sierra Iron Co., c/o D. H. Botchford, pres., 3851 Santa Fe Ave., Los Angeles (now at Multnomah Hotel, Portland, Ore.), D. F. Hawkins, vice pres. and genl. mgr., Vancouver, plans constructing 500 ton daily capacity iron reduction plant. $600,000.

Ont., Kapuskasing—Transcontinental Paper Co., Ltd., 25 King St. W., Toronto, plans constructing pulp and paper mill and equip. $500,000. Site purchased.

Mexico, Comales—Mexican Govt., c/o Irrigation Comn., Mexico City, surveys start soon, replacing large machine shop unit of electric power plant on San Juan River across from Rio Grande River, 22 mi. southwest of Rio Grande City. $125,000.

South America, Colombia—American Commercial Attache, Bogota, reports a bill is before Columbian Legislature which will authorize the Government to proceed with studies, plans, specifications and cost estimates for constructing hydro-electric plant on Cauca or Palo Rivers. Dpt. Cauca, would supply electric energy to municipalities of Calota, Santander, Puerto Tejada, Corinto, Miranda, Calondo, Buenos Aires, surrounding territory for future requirements of Pacific R.R.

SAFETY WITH *Seamless*

TEN YEARS AGO a remarkable development made its appearance in the flexible metal hose and tubing world. It was seamless metal tubing with all the flexibility of a garden hose.

Since then American Seamless Flexible Metal Tubing has found its way into thousands upon thousands of different applications, each making valuable use of one or more of its unique properties... such as:

No joints, welds, laps, seams or packing where leaks can occur.

It has been flexed millions of times without breaking down.

Available in various alloys, corrosion resistant and strong, and thus useful for *all* industries.

Braids and casings make it as strong, as tough as pipe; but in addition, it's flexible.

In other words, American Seamless is the most dependable tubing you can buy for the conveyance of steam, air, gases and liquids... for connecting moving or misaligned parts. You can read more about American Seamless in SS-25, a 24-page book of facts illustrated by more than seventy-five pictures. Ask for it—no obligation. 40239

In air-conditioning systems, American Seamless eliminates vibration from compressor. See page 12 in Bulletin SS-25 for complete information.

American Metal Hose

ANACONDA
from mine to consumer

The American Metal Hose Branch of The American Brass Company
General Offices: Waterbury, Conn. *Subsidiary of Anaconda Copper Mining Company*
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Formula for Kings . . .

"GEORGE," said the Boss, about a year after I'd got to be chief, "you come as near being a king as anybody I know. You know more about power and how to produce it than I do, or anybody that works for you. I depend on your decisions on what's to be done and what's not to be done. As Cervantes said, 'You are a King by your own Fireside as much as any Monarch in his Throne.'

"I'm not figuring on doing any preaching. I just want to stress one thing that can sneak up on you almost without your knowing it. You can get to liking your authority so much that you won't listen to anybody else—either boss or bossed. That one thing might be the lost nail that will cost you your little kingdom.

"Don't get me wrong—you've got to be sure of yourself. You've got to know how to do each job as well as the man who's doing it—but you've also got to realize that some other way of doing it may be as good as yours. Within reason, let the boys working for you have their heads—and in so doing develop their self-confidence and power to think, too.

"Within the limits of your ability, you can be what you aim to be—but you can't get there all alone. Aim high. Set a mark for yourself and do your darndest to reach it. Nobody can be as much interested in your career as you are yourself. But be honest and fair about it. Remember that as you take a step up, your new responsibilities force you to release some of the old ones. Let the men working for you take them over—they've got ambitions too—and by helping them you help yourself."

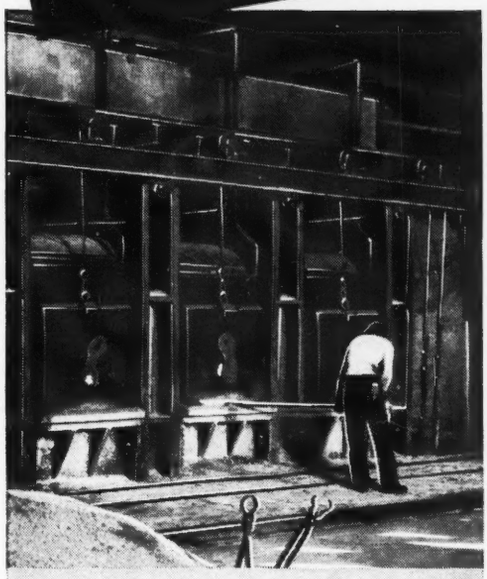
That's all there really is to any formula for success.

George Edwards

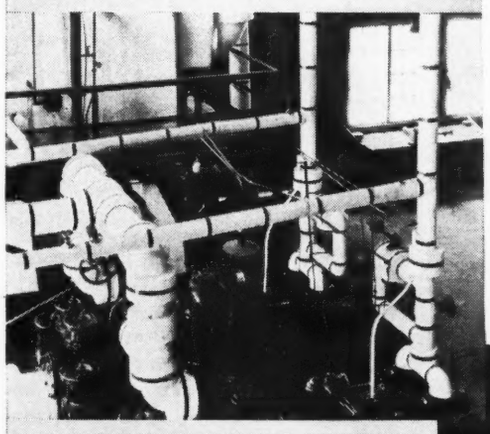
Engineer

ARE YOU GETTING YOUR SHARE OF THIS $250,000,000 A YEAR?

Over a quarter of a billion dollars . . . that is the staggering amount J-M Insulations save American Industry *every year* by reducing fuel and refrigeration costs. And here is how you can be sure your plant receives its full share of this huge saving . . .



$11,000 ANNUAL SAVING—In 1927, the regenerators and flues of this open-hearth furnace in a large Ohio steel foundry were insulated with Johns-Manville materials, applied in accordance with the recommendations of a J-M Insulation Engineer. The net fuel savings *every year* have been more than 400% of the cost of insulation.



SAVING FUEL, INCREASING EFFICIENCY—This power plant is typical of hundreds all over the country that are saving thousands of dollars in fuel annually because all their equipment and piping is correctly insulated with the right types and thicknesses of J-M Insulations.

THERE is only one way to assure maximum fuel savings and greatest operating efficiency . . . that is by using the *correct thickness* of the *right insulation* for every service.

And there is one sure way to solve the problem once and for all . . . call in a J-M Insulation Engineer. Let him study your requirements . . . if your present insulations are correct, he'll tell you so. If not, he will prepare a complete recommendation showing the most efficient and economical types and thicknesses of insulation for every piece of equipment in your plant. Furthermore, he'll be glad to prove just how they will give you better heat or refrigeration control and save you money far beyond their cost.

Back of these engineers stands Johns-Manville's 80-year leadership in the development and manufacture of insulations . . . the largest, best equipped Thermal Insulation Laboratory in the world . . . and a complete line of insulating materials in block, brick, cement and pipe-covering form for every temperature, for every service condition.

Why not phone for a J-M Engineer today? His services are free . . . and you'll find one or more in every large city throughout the country. Or, for complete details on J-M Insulating Materials, write for Brochure IN-55A. Address Johns-Manville, 22 East 40th Street, New York, N. Y.

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INDUSTRIAL INSULATIONS

for every temperature . . . for every service condition

1 SEAMLESS
2 UNIFORMLY FULL PIPE THICKNESS
3 SELECTIVE, UNIFORM REINFORCEMENT
4 TANGENTS
5 MACHINE TOOL BEVELLED
6 ENDS MARKED IN QUARTERS
7 COMPLETE IDENTIFYING MARKS ON EVERY FITTING
8 A FULL LINE

THE man who said "welding fittings are just welding fittings" will please note these eight features that are combined only in Taylor Forge WeldELLS.

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Seamless Pipe Fittings for Welding

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Stoker Flexibility

(Continued from page 69)

crusher, air-cooled Taylor stokers (314 sq ft) fire five 12,000-sq-ft cross-drum boilers fitted with 22,000-sq-ft tubular air heaters. Each furnace has vertical-tube water-cooled side and bridge walls, and plain refractory front walls. Four of these units carry the average plant load of 300,000 lb per hr, at 300 lb, 475 F, with peaks that frequently run to 345,000 lb. The minimum steam demand of 200,000 lb can be handled on 3 boilers. At the average rate of 300,000 lb, or 75,000 lb per hr per boiler, gas enters the preheater at 590 F and leaves at 300; air leaves the preheater at 400 F; feedwater enters the boiler at 214 F. The yearly fuel consumption, when using straight bituminous, was 75,000 gross tons.

Previous experiments in burning a mixture of anthracite and bituminous were abandoned because of inability to secure anthracite at an attractive price. When the crisis began to deepen last April, the operators decided to again experiment with a mixture of the two coals, as a safety measure to conserve the supply of bituminous.

Coal comes to the plant dock by barge; a locomotive crane and grab bucket handle unloading. To make the "blend", two buckets of bituminous join one of No. 4 Buckwheat anthracite in a crusher feeding onto an inclined belt conveyor leading to the bunker. The resulting mixture averages 30% anthracite and 70% bituminous, by weight. Experience shows this best for continuous use, and no reduction in capacity has been noted. Increasing the percentage of anthracite curtailed capacity on peaks only.

The mixture of fuels does not adversely affect stoker reliability; in fact, stoker maintenance runs less. The more porous condition of the fuel bed minimizes formation of hard clinker, as evidenced by the fact that no pins sheared while burning this mixture. For 1938, the actual evaporation (average) was 11.10 lb, using straight bituminous; for 3 months with the 70-30 mixture, the evaporation averaged 10.41 lb. Based on the present price of No. 4 Buckwheat anthracite, operators have decided to continue use of the mixture.

✦ ✦ ✦

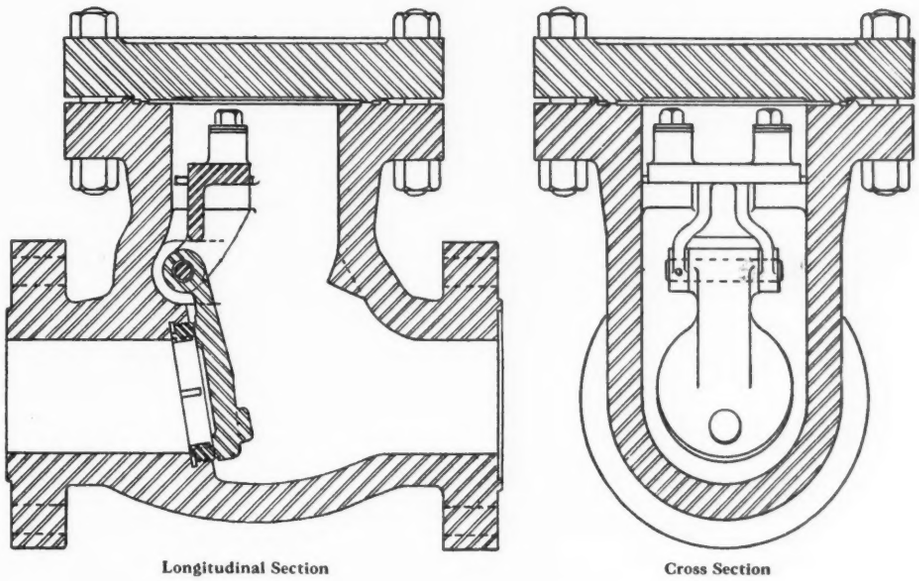
NEXT MONTH

In May POWER, watch for 4-page report on the status of outstanding utility plants now abuilding.

In a Class by Itself !

This New Design by

Chapman



Longitudinal Section

Cross Section

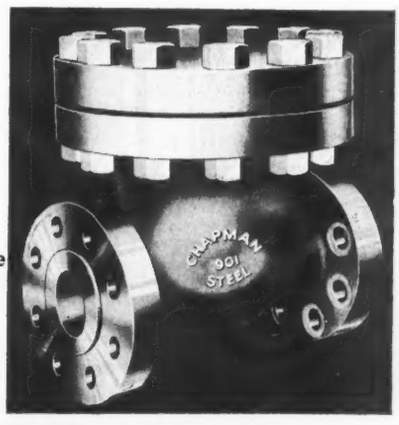
CAST STEEL SWING TYPE CHECK VALVE

The improved line of Chapman Steel Swing Type Check Valves for high pressure service, offers several important advantages over the conventional design of swing type check valves.

The outstanding features are the *one-piece* disc, arm and hinge assembly bolted directly to lugs cast *inside* the valve body.

This integral disc, arm and hinge assembly does away entirely with the usual loose-bolted connection between disc and arm, which is subject to excessive wear and has always been a primary source of trouble. With this disc, arm and hinge assembly entirely inside the valve, no perforations are needed through the valve body for hinge pins or assembling. This eliminates possibility of leakage and any need for outside clearance to remove the hinge pin. The assembly of disc arm and hinge pin is self-aligning, and the disc will always align itself with the seat ring.

The Chapman Steel Swing Type Check Valve, with its exclusive, service-tested features which place it in a class entirely by itself, is now available for all pressures from 150 to 1500 pounds.



Chapman Steel Check Valve A. S. A. Rating Carbon Steel 900 lbs. at 750 degrees F.

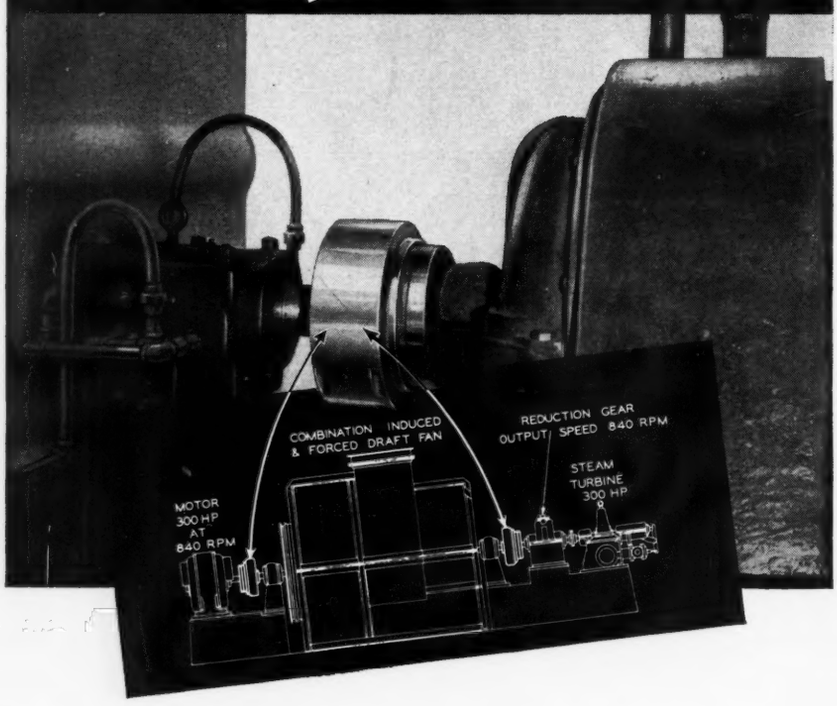
THE CHAPMAN VALVE

MANUFACTURING COMPANY

INDIAN ORCHARD, MASS.

ANOTHER MIDWEST POWER PLANT *Installs*

MORSE FREE-WHEELING CLUTCHES

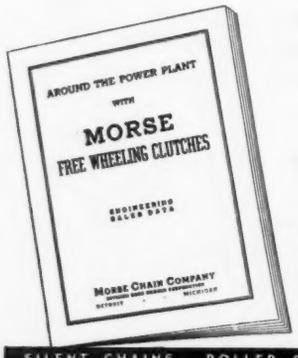


Illustrations show a typical Morse Free-Wheeling Clutch application, now on its fifth year of service in a well-known midwest steel-mill power plant.

This combination induced and forced-draft fan, driven through Morse Free-Wheeling Clutches, by dual drives, *never need stop or slow down.*

The combined power of motor and turbine may be used—or either unit may be operated separately without shut-down, the idle unit remaining inoperative.

With Morse Free-Wheeling Clutches, dual-drive operation is greatly simplified—more economical—more efficient. No power is wasted, turning an idle driver. No danger of damaging turbine rotor or motor windings. No necessity for cumbersome "cut-out" couplings.



Send for Clutch Engineering Bulletin

"Around the Power Plant with Morse Free-Wheeling Clutches" contains helpful, practical data you should have—interesting diagrams of typical power plant applications. Write for your copy today!

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS KELPO CLUTCHES

MORSE *positive* DRIVES

MORSE CHAIN COMPANY, ITHACA, N. Y. • DIVISION BORG-WARNER CORP.

Argument Corner

(Continued from page 108)

shell sitting on the brickwork, just a throwback from Watt's wagon-top boiler or the egg-ended boiler of a hundred years ago or more. And the pressures! Heck, they were only a "hunnert pound." Some went up to a hundred and fifty, but they were few. In some cases the steam was used to drive a steam engine, *and the exhaust* went up the exhaust pipe, *into the atmosphere!* Scandalous waste!

I wandered into the "big" power houses and saw water-tube "Bilers." But what were the pressures? 200 pounds, 250 pounds! A new boiler was put in a plant not far from where I was living. A huge boiler . . . high pressure, too . . . 300 pounds. That was high. Then one day another crazy article on "American High Pressure Practice as . . . etc."

The jute mills in Dundee had higher pressures. One plant had six B&W water-tube boilers, 225 pounds, built in 1905, and a lot more plants had similar boilers throughout the Island. There was one thing, though. Steam never bellied from these plants into the atmosphere. No sir! Every plant was condenser-operated. We Scots did not fall back on Jimmie Watt. The only difference with the factory condensers was that they were not of the surface type. They were atmospheric condensers.

Above the engine house one could see a series of inverted "U" pipes, and, believe me, there were engines under that roof, too. Engines I have never seen the size of in North America. Vertical cross-compounds, triple-expansion Corliss engines, and horizontal types by the dozens. Mill shafts, as in the Old Ashton Works, almost a mile long. Rope drives were the order of the day, but, like everything else, they went for centralized power. I could go on blathering about the mill power plants till doomsday, but the main fact remains, they don't build "Bilers" and put fire under the shells, and all steam engines are condensing, even some of the steam locomotives. All except traction engines "down on the farm." As for high pressures, phooey! The average in Scotland is higher than in the U. S. Sure, for every boiler in Scotland, there are a "hunnert an' fifty" over here.

This is just to let you remember that the next time you write anything, be sure a Scotsman doesn't read it.

Grand Rapids, Mich.

JOHN M GORRIE

"A RECORD FOR CONSTANT OPERATION"

Trouble-free turbine means trouble-free operation for prominent fuel company.

A case history showing the trouble-free service you can expect wherever you see the Coppus **BLUE RIBBON**

"This turbine pump has performed 24 hours a day for more than three years and has never been shut down . . . is still operating 24 hours a day, and we have never had any maintenance cost of any kind on either turbine or pump. This is a record for continuous operation for any piece of machinery we have ever installed."

To insure consistently dependable operation of turbine-powered equipment, write "Coppus" on your specification. The "blue ribbon" painted on the flange indicates:

1. **PRECISION WORKMANSHIP**—controlled by Johansson size blocks.
2. **ENCASED GOVERNOR**—slow speed, leverless.
3. **SEPARATE SAFETY TRIP**—pilot-operated, leverless.
4. **PARTIAL LOAD ECONOMY**—by individual nozzle control.
5. **DYNAMOMETER TESTED**—before shipment.

During 1939, 87% of orders for Coppus Steam Turbines were repeat orders. Bulletin 135-9 describes vertical and horizontal types; also with built-in speed reducer. Steam, air or gas-operated. Write for this bulletin today.

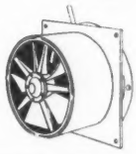
H. P. not E. P.* for small H. P. jobs.

*Elephant Power—a large-size turbine for a job a small-size Coppus could handle. Save investment cost with a Coppus Turbine sized close to your needs.

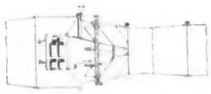
COPPUS ENGINEERING CORP., 350 Park Ave., Worcester, Mass. Sales offices in THOMAS' REGISTER. See SWEET'S for other "Blue Ribbon" products—air filters, gas burners, blowers, ventilators, fans.

COPPUS BLUE RIBBON PRODUCTS

Designed for your Industry
Engineered for You

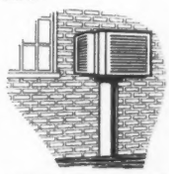


COPPUS-DENNIS FANMIX GAS BURNER. New method of mixing gas and air insures perfect gas-air ratio—instant, complete combustion. Bulletin 410-2.



COPPUS VANO BLOWERS. 1001 uses. High efficiency on special installations where ordinary fans fail. Bulletin 115-6.

COPPUS CABLE MANHOLE AND TANK VENTILATORS. For any confined working space. Special adaptions for boilers, tank cars, shipholds. Bulletin 163-1



COPPUS AIR FILTERS. For engines and air compressors. Perfect, uninterrupted filtration. Bulletin F-310-4.

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Engineers' Books

Electricity

THE PAGEANT OF ELECTRICITY (1939). *By Alfred P Morgan, Published by D Appleton-Century Co, Inc, 35 W 32nd St, New York, N. Y. 363 pages, 5½x8½ in., illustrated. Price $3.50.*

In recent years many attempts have been made to popularize science and engineering, with varying degrees of success. This book is one of the really successful ones. It is romance, drama, biography and the history of the science of electricity and magnetism all woven into a delightful literary fabric.

Starting with the Greek philosopher Thales who created the science of geometry of lines in 600 BC and who was probably the first man to observe the effect of static electricity, the fascinating story of electricity and magnetism down to the present day is revealed through the work of Roger Bacon, Galvani, Volta, Oersted, Faraday, Morse, Edison, Bell, Pupin, Marconi and many others. These men become vivdly alive along with other adventurous spirits who braved hardships, ridicule and even solitary confinement in prison to explore a universe of unknown forces. Here also is told the story of the development of the telegraph, telephone, power generation, wireless communication, electricity in transportation and electrochemistry.

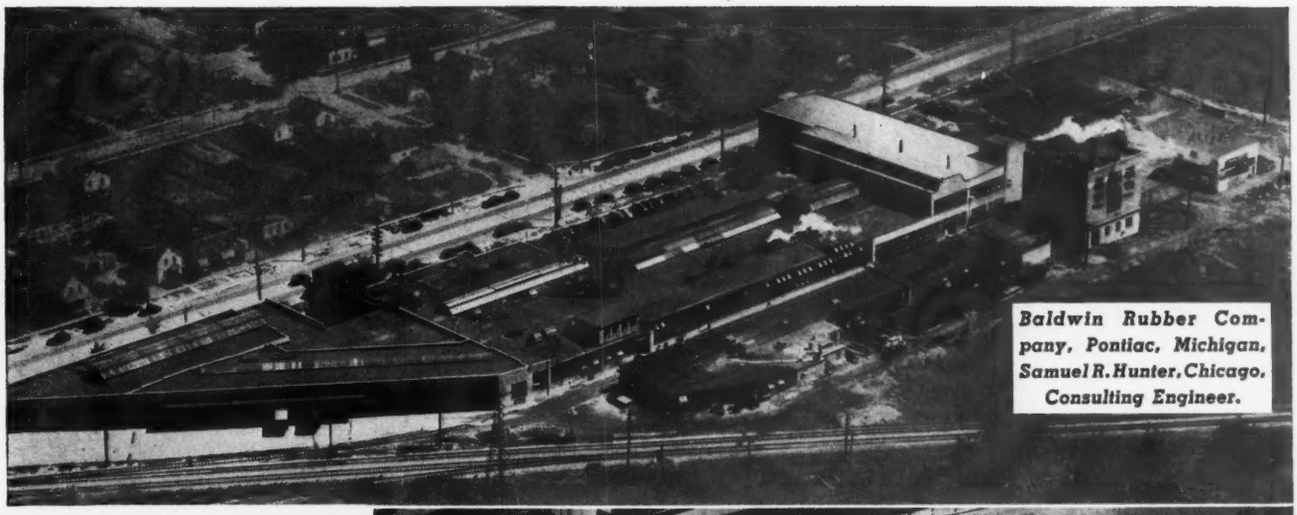
This book is no dry technical chronicle but one of those vividly living stories accurately told, that every one can read with pleasure as well as profit. Wherever technical explanations have been attempted, and there are some excellent ones, they are given in connection with illustrations and are not a part of the narrative. The chronology of 140 important dates in the history of electricity and magnetism and a comprehensive index make the book a valuable historical reference on outstanding men and events in the discovery and use of electricity and magnetism.

Science

EXCURSIONS IN SCIENCE (1939). *Edited by Neil B Reynolds and Ellis L Manning. Published by Whittlesey House, McGraw-Hill Publishing Co. Inc, 330 West 42nd St, New York, N. Y. 307 pages, 5½ x 8 in. Price $2.50.*

In May, 1936, the General Electric Co instituted a radio program, called "The Science Forum," designed to present the meaning, scope and purpose of modern scientific research and engineering in language that could be understood by laymen. As part of that program, workers in many fields of science were invited to present short talks on their particular field of study. In this book the editors have presented a selected group of these talks in a style that makes instructive and interesting reading.

These 35 short articles deal with sub-



Baldwin Rubber Company, Pontiac, Michigan, Samuel R. Hunter, Chicago, Consulting Engineer.

Abrupt Load Swings Easily Met By DETROIT ROTOSTOKERS at Baldwin Rubber Company

PONTIAC, MICHIGAN

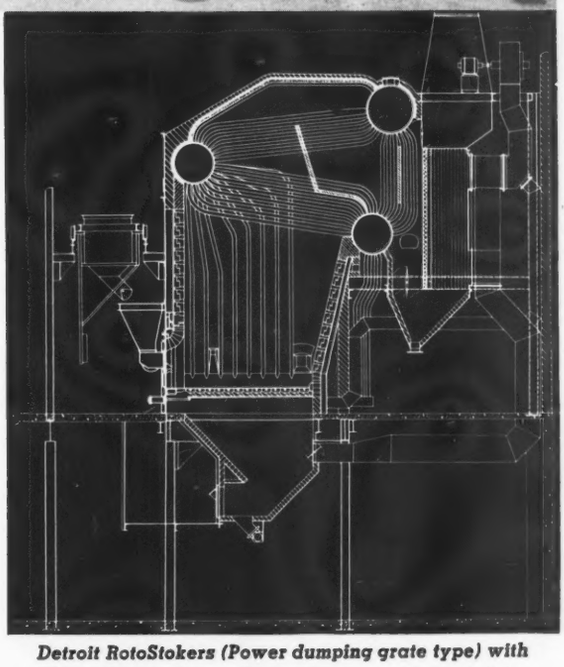
Angus McDonald, Master Mechanic

The steamflow rate at this plant varies from 8500 to 25,000 pounds per hour, due to highly fluctuating process demands. These load swings are 6 to 10 times per hour.

Detroit RotoStokers have no difficulty in following these fluctuations—with steady steam pressure and a combined average efficiency of over 80%.

Detroit RotoStokers successfully burn a wide range of fuels—handle fluctuating loads easily. They are sturdy, long lived—satisfactory.

Write for Bulletin 830.



Detroit RotoStokers (Power dumping grate type) with Three Drum Steam Generators. . . . Designed for 450 lbs. pressure, 725° F. steam temperature with 300° F. preheated air.

DETROIT STOKER COMPANY

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Watch for these "handbook" articles

1. Alternating-current motors—April.
2. Diesel data—200 plants—June.
3. Engineering data on 400 modern steam and hydroelectric plants—September.
4. Principles and practice of combustion—December.

It Pays You to Read POWER Regularly

jects associated with our work-a-day lives, which most of us would like to know more about. Some of them are: atoms and their family relations, time, nature of lightning, marks on your thermometers, vacuum, power from the sun, ozone, adventures with the atom, men and metals, what happens in a gas-discharge lamp, how radio tubes work, fluorescence and phosphorescence, and a gage that measures a millionth of an inch. Even though these articles are written for laymen, most engineers will find them entertaining reading as well as useful references.

Leather Packing

HYDRAULIC AND PNEUMATIC LEATHER PACKING DESIGN AND APPLICATION. (1940). *Published by Chicago Belting Co, Green and Washington Sts, Chicago, Ill. 50 pages, 8½ x 11 in., illustrated, paper binding. Free to heads of engineering departments and designing engineers only in industrial plants using packing either for replacement or in standard equipment.*

Engineers in most plants do not have hydraulic packing problems every day but when they do, they need an authoritative source of information such as this book. Four types of leather packings: cup, flange, U-shaped, and nested-V packings are considered.

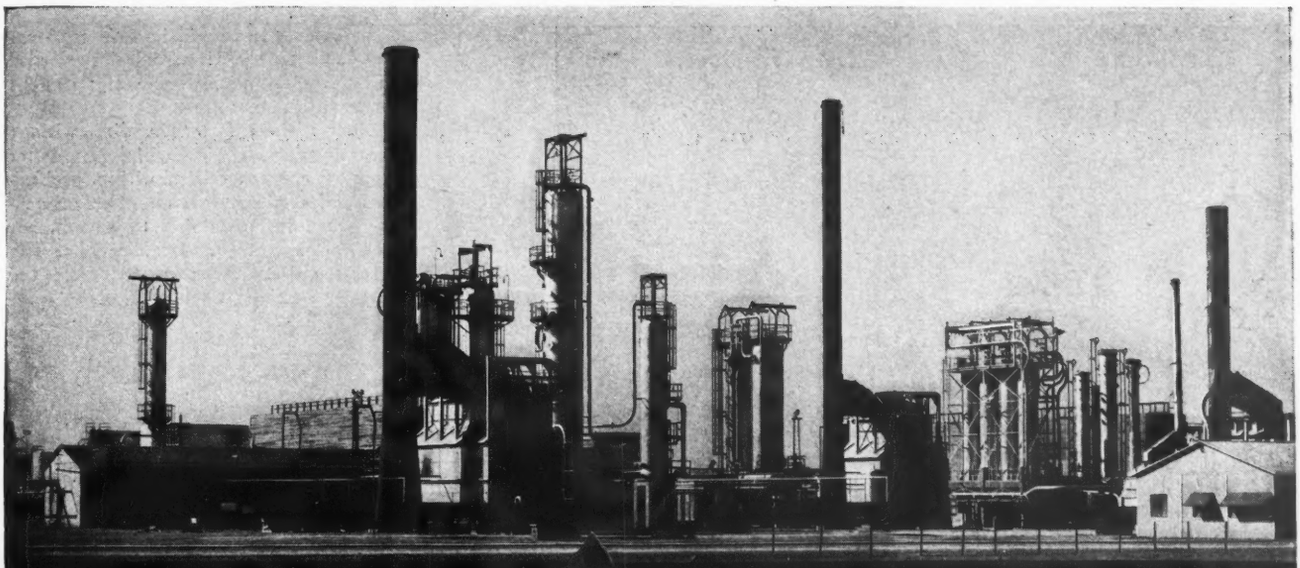
Such subjects are discussed as metal parts, gland rings, piston plates and clearances; bolts, studs and piston rod shoulders for cup packing; leather grips for cup and flange packings; heel-corner radius, lip bevel and flared U and cup packings; surface speed at various pressures; temperature limits; choice of packing style; packing specifications; and 18 don'ts for hydraulic and pneumatic packings. The subjects are presented in practical every-day language; the many dimensional and other sectional illustrations make the book a valuable reference for everyone interested in packing problems.

Electric Wiring

INTERIOR ELECTRIC WIRING AND ESTIMATING (1940). *By Albert Uhl, Electrical Contractor, Arthur L Nelson, formerly Superintendent, Interior Wiring Dept, Commonwealth Edison Co, and Carl H Dunlap, Head, Electrical Engineering Dept, American School. Published by American Technical Society, Drexel Ave at 58th St, Chicago, Ill. 342 pages, 5½x8½ in.; 332 illustrations; 41 tables, cloth binding. Price, $2.50.*

Standards of practice for electric wiring have been set up by engineering societies and boards of underwriters to obtain greater safety for public and property. In spite of all this, economy remains as one of the major problems in electric wiring, and only through acquaintance with up-to-date appliances and methods can this job be done and estimates given to provide adequate and economical wiring installations, a point of view that prevades this book.

(Continued on page 142)



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For industrial and other engineers who have electrical equipment to install and maintain—here is a *complete* resistance-measuring outfit all built into one portable set that weighs only about 13 lbs. With it you can test the insulation of all types of electrical equipment and detect and forestall trouble. You can measure coils, contacts and relays. You can locate many troublesome faults. The set is portable and rugged—suitable for every day hard use.

Let us tell you more about this unique instrument that has the remarkably wide range of .01 ohm to 200 megohms. Self-contained constant-pressure generator rated 250, 500 or 1000 volts d.c. Write for descriptive Bulletin 1615-P.

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1211-13 ARCH STREET *Electrical and Scientific Instruments* PHILADELPHIA, PA.

The volume is divided into six sections: knob and tube wiring; interior electric wiring; conduit wiring materials; conduit wiring, tools and methods; apartment-building wiring; factory-building wiring; and estimating electrical wiring. The latter comprises chiefly electrical-wiring specifications and answers to 54 questions on general principles pertaining to amounts of electrical materials and labor costs. The various subjects are presented from the practical man's viewpoint.

Instruments

PRESSURE GAGES, INDICATORS, THERMOMETERS AND PYROMETERS (1939). *By James Smith. Published by Chemical Publishing Co, Inc, 148 Lafayette St, New York, N. Y. 144 pages, 4½ x 7 in.; 116 illustrations; 11 tables, fabroid binding. Price $1.50.*

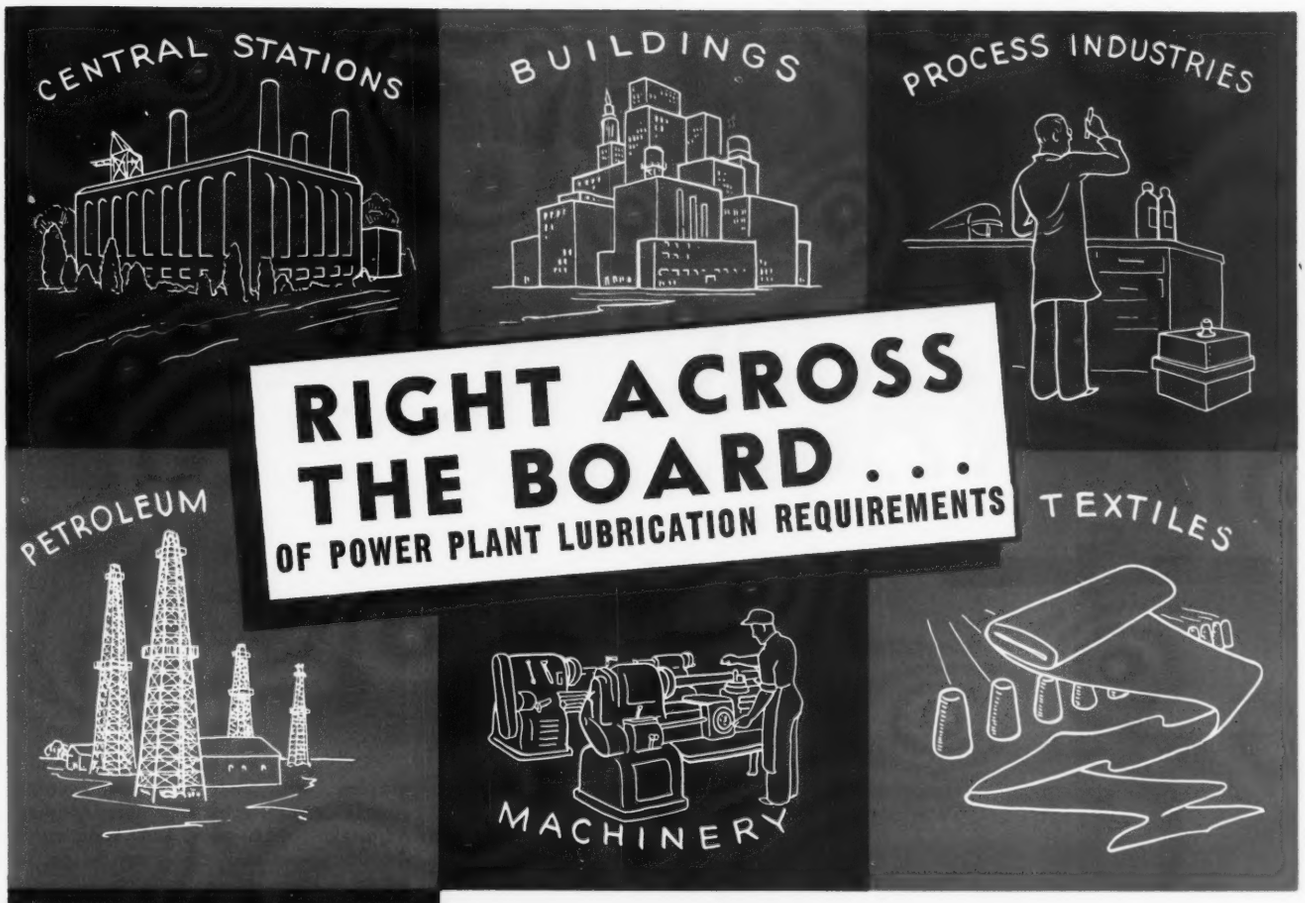
Here is a book on gages and indicators that the practical operating engineer can read and understand. It is divided into 19 chapters covering barometers; measurement of high and low pressures and vacuum; testing of pressure and vacuum gages; gage errors and troubles and how to correct them; steam-engine and diesel-engine indicators and how to take and interpret indicator diagrams; liquid-level indicators; measurement of temperature including the use of fusion- and expansion-types, thermo-electric, electrical-resistance, radiation and optical pyrometers. Construction and operation of each type of indicator and gage are clearly shown by sectional and other types of drawing.

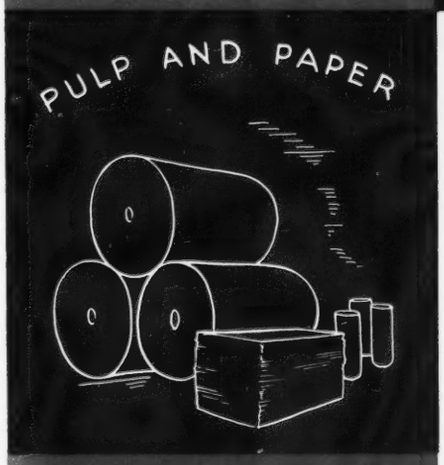
Plumbing

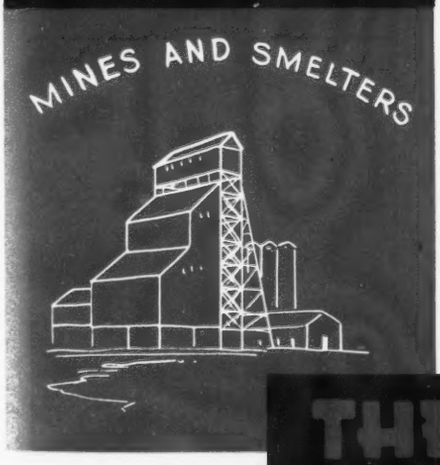
HOW TO DESIGN AND INSTALL PLUMBING (1940). *By A J Matthias, Jr, Circuit Instructor of Plumbing, Wisconsin Vocational Schools; Licensed Journeyman Plumber. Published by American Technical Society, Drexel Ave at 58th St, Chicago, Ill. 388 pages, 5½ x 8½ in.; 330 illustrations; 30 tables; cloth binding. Price $3.00.*

Plumbing is characterized as the hub of modern sanitation and is considered by many authorities to be the most scientific of all building and industrial trades. Its prime purpose is to safeguard the health of people by disposing of fecal wastes and provide a satisfactory supply of pure, wholesome water. Every engineer in public buildings and industrial plants has this work as part of his many responsibilities.

This book in 27 chapters treats of plumbing problems associated with all kinds of sanitation work from municipal sewage disposal to drinking fountains. Among the more important subjects covered are: private sewage disposal, materials for sewer pipe and fittings and how they are used; house sewer and drain appliances and how to install them; traps used in plumbing systems; inspections and tests, pumps and lifts, cold- and hot-water distribution system, cold-water distribution in tall buildings; sanitary facilities, etc.







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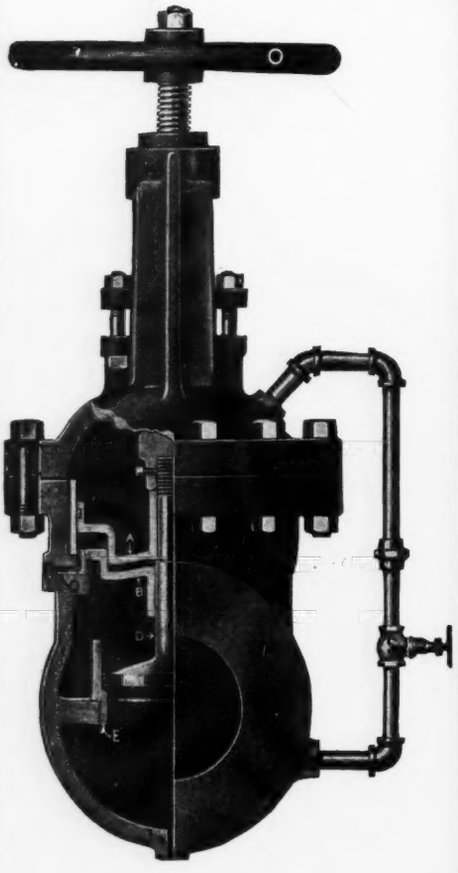

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GOLDEN-ANDERSON VALVE SPECIALTY CO.

FULTON BLDG. PITTSBURGH, PA.

New Plant Equipment

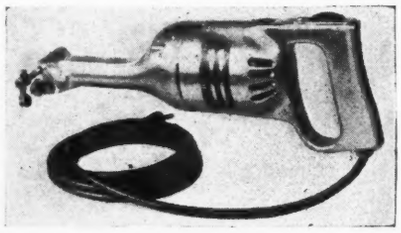
(Continued from page 124)

cause blades flatten out and take no power. Only adjustment is through thermostats, and maker claims that life of fan belts is increased.

Kontrol-Fan, Inc, Pasadena, Calif.

Mica Undercutter

IDEAL direct-drive undercutter is for field or shop use where motor- or brush-rigging is not removed. Other types are available designed for jobs where brush rigging has been removed. Direct-drive unit is

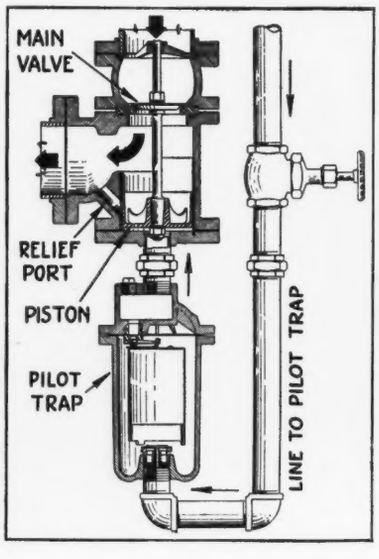


complete, with motor and undercutting mechanism cased in aluminum castings. Adjustable depth-gage and roller-guide simplify operations. Slots may be cut to within 3/16 in. of commutator riser.

Ideal Commutator Dresser Co, 1025 Park Ave, Sycamore, Ill.

Giant Steam Trap

ARMSTRONG trap has 6-in. pipe connections and continuous flow capacity for 300,000 lb per hr of water at 50-lb pressure. Originally built for draining evaporators in sugar refineries, it is now offered for automatic-drainage of large steam purifiers, separators, flash tanks, blowdown systems, etc. Consists of large inverted bucket-type pilot trap and a piston-operated main valve, main valve assembly being installed as an elbow in the drain line. Pilot trap is connected to drain line at a point above



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MANHATTAN engineers will work with you to select the size, type of construction and grade to fit the material, the length of haul, the degree of lift and all the other factors which will give you a high return in service and economy.

If it isn't quite time to order, you can get preliminary information by writing for Bulletin 6862.

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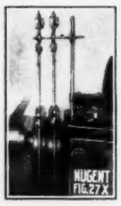
Sight Feed Oiler Removable glass to clean while oil is running.

Oil-From-The Floor Shaft Oiler. Fifteen feet off the floor



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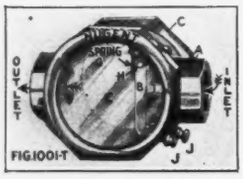

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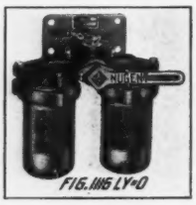

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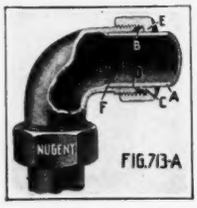

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main valve assembly, and main valve is sealed with water in this manner. Operating cycle begins with flow of condensate to pilot trap, which discharges against piston of main valve, forcing piston upward until relief port is uncovered. Because piston head area is greater than main valve cross-section area, it is possible to open main valve against any pressure. Upward movement of piston is checked by using piston skirt to cut down area of the main outlet port. Snap action closing takes place when steam, instead of water starts coming into pilot trap and causes it to close. Use of the inverted bucket trap, according to maker, makes the unit non-air binding.

Armstrong Machine Works, 812 Maple St, Three Rivers, Mich.

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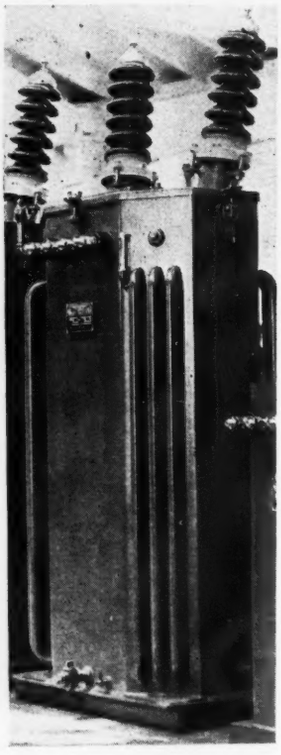
NIAGARA transformers have coils designed to provide maximum dissipation of heat by means of well-circulated oil. Overheating and hot spots are prevented by correctly located oil-ducts. These coils are dried in electrically heated and electrically controlled ovens and then vacuum-dried to remove all air and moisture. They are then pressure-impregnated with clear varnish of high dielectric strength. Cores for unit are cut to size with smooth edges free from burrs. In stacking, strength is



increased and reluctance reduced by interlocking and staggering successive layers of laminations. Cores are insulated from coils and frame by heavy pressboard. Transformer tanks are fabricated from non-scaling steel and each style is designed to provide ample room for bushings and accessories. When completed they are tested by being filled with transformer oil and allowed to stand for 24

SAVE FEED WATER COSTS WITH FERRISUL

Oil is needed for lubrication but when it gets into boilers—watch out! The result can mean bagged sheets and blistered tubes as well as loss of time and money for correction.

The easy way to forestall oil trouble in boiler feed water is through the use of Ferrisul (anhydrous ferric sulfate). Used in condensate waters, Ferrisul gives complete removal of emulsified oils.

A safe and dependable coagulant for pretreatment of boiler feed water, Ferrisul is effective at all water temperatures, removing silica in a quick-settling floc and leaving no scale forming residues. The Ferrisul floc is stable over the entire pH range above 3.5.

Further information will be gladly supplied by Monsanto's technical staff. Inquire: MONSANTO CHEMICAL COMPANY, Merrimac Division, Everett Station, Boston, Massachusetts.

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For
Boiler Water Treatment

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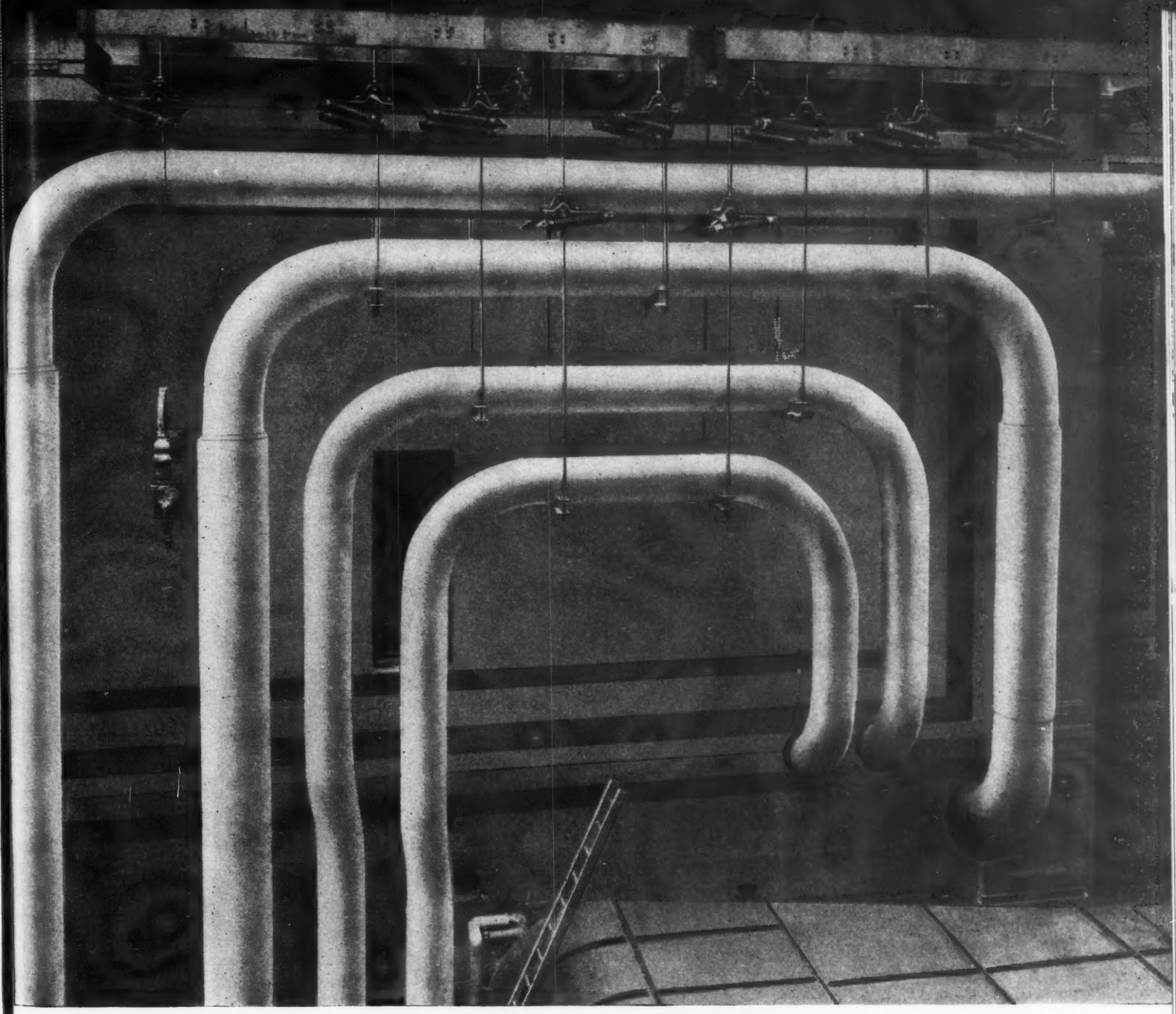

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HOW TO INSTALL *"Weightless"* Piping Systems

Stress calculations for high temperature piping have assumed new importance since Grinnell *Constant-Support* Hangers provided a way to stabilize external stress factors. Complete systems now may be considered "weightless" because deadweight of piping is uniformly and continuously balanced . . . regardless of thermal movements!

Here is the first hanger designed specifically to give this proper support. Made for loads from 250 pounds to 8500 pounds, the Genspring Hanger adjusts itself to changing elevations of the piping, and automatically compensates for variations in its own spring tension.

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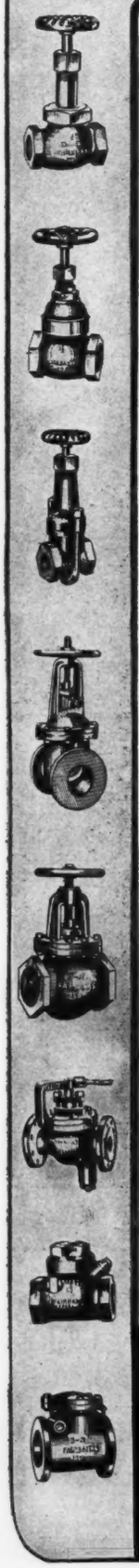

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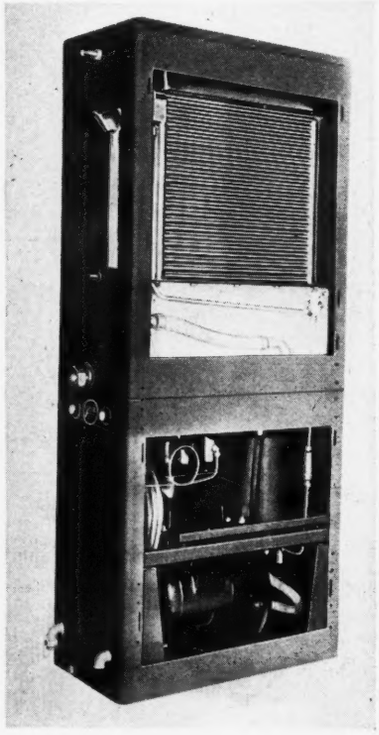
Industrial-Type Water Cooler

SMALLER than York "High-K" stainless-steel plate water cooler, new "Cold-Well" cooler, in 3 and 5-hp models, is designed for small-scale industrial operations—notably bottling. Temperature-selector dial is set for any desired uniform temperature from 34 to 50 F. To insure sanitation,



stainless-steel is used for entire water circuit—distributor, cooling plates, and reservoir. Refrigeration is supplied by York unit in base. Cooler is package-assembled in modern-style cabinet, charged with refrigerant and tested before leaving factory. Supplied in four models: light-duty, 3 and 5 hp; heavy-duty, 3 and 5 hp.

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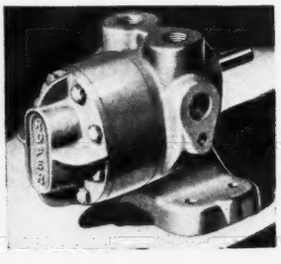

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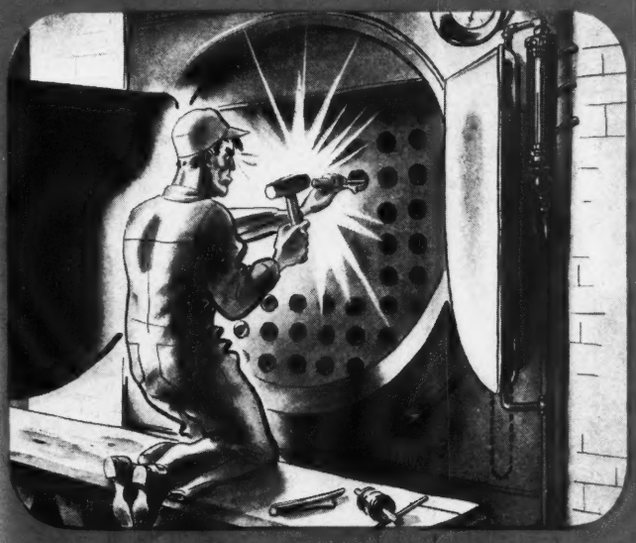

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SCALED-UP PUMPS—The sodium hexametaphosphate and organic reagents in Dearborn Treatment prevent precipitation and filling up of feed lines, feed pumps, valves, and heaters.

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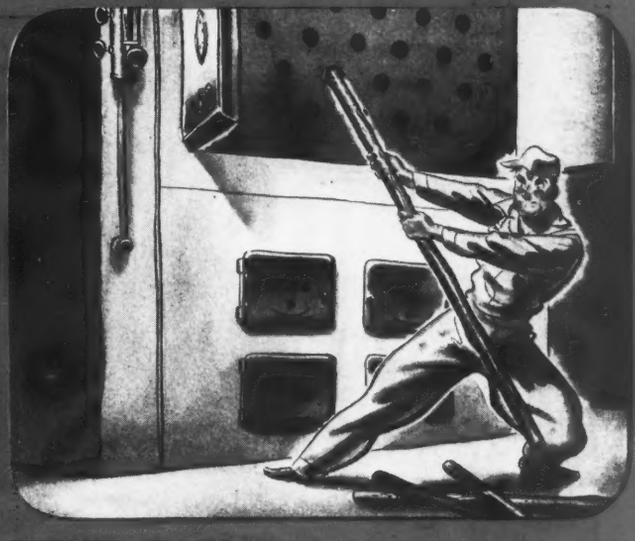

BURNED FLUES—Boiler surfaces are kept clean with Dearborn Treatment, preventing tube burnouts and bagged sheets. Let Dearborn take the responsibility for your feed-water problems.

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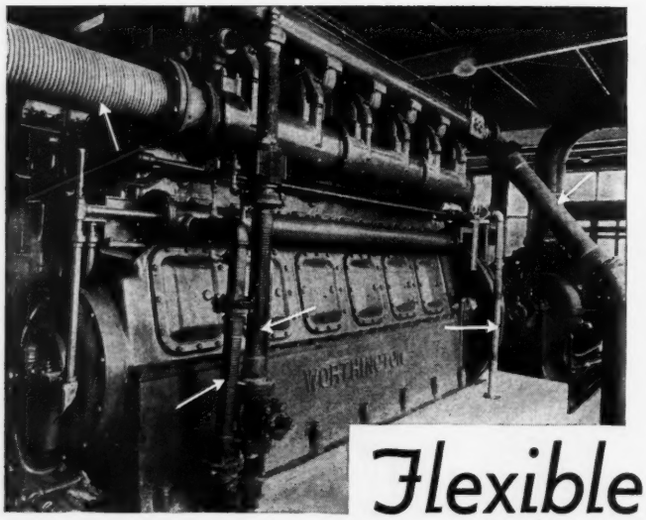

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Bul. 70

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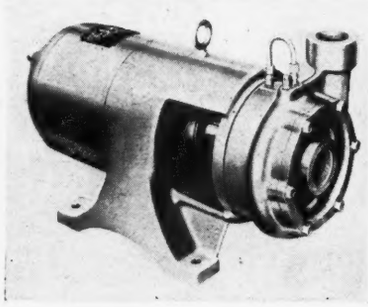
ture of new pumps said to be "hydraulic balance", which equalizes internal pressure at all points and absorbs all shock or thrust from power end of drive shaft. Other features include choice of gears, conventional packing box, spring-loaded packing box or mechanical seal, sleeve or roller bearings, built-in or external relief valve, and eight different piping arrangements.

Geo D Roper Corp, Rockford, Ill.

Centrifugal Pump

MONOBLOC centrifugal pumps have pump and motor built integral with each other, and come in sizes from 1 to 4 in. with capacities to 100 gpm against heads up



to 280 ft. Pumps require minimum floor space, yet have ample room for repacking stuffing box. Drip-proof motor features a direct flow of ventilating air which prevents drawing of moisture into motor.

Worthington Pump & Machinery Corp, Harrison, N. J.

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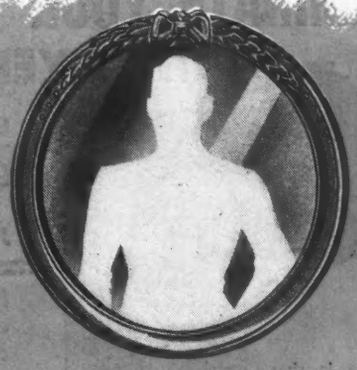
PORTO-RECT units, developed for use with machine tools, use latest-type hot-cathode mercury-arc tubes guaranteed for 2000 hours under normal operating conditions. These have over-all efficiency as high as 90% at full load, and no-load losses are said to be as low as 60 watts. Unit in

simplest form consists of a bank of tubes and an auto or isolating transformer. To this is added voltmeters and ammeters as need arises, or unit can be equipped with variable voltage controls. Can be furnished for use on 110- or 220-volt single-phase ac circuits, with 115 or 230 volts, 12 to 90 amp dc output; and for use on

Can you see your reflection in this story of the Western Glass Co.?



Replacing rustable piping with copper tube saves mirror manufacturer $100 every two years

INSIDE this mirror silvering table at the Western Glass Co., in Denver, there is now a network of copper tube. It is two years old and seems as good as new. How different was the story when ordinary pipe was used for the same purpose! Every two years it was necessary to tear the table apart to remove and replace the rusted-out pipe—at a total cost of $100 per replacement. Yet this copper tube installation, using 1½" Anaconda Copper Tube, cost but $50 more than the rustable job.

Perhaps there's a place in your plant, too, where copper tube can save you from the upkeep and replacement expense due to rust. If there is, have your maintenance department or plumbing contractor give you the cost of a complete copper tube job. You'll know then why Anaconda Copper Tubes are today's best buy in piping. 4002A

ANACONDA
From mine to consumer

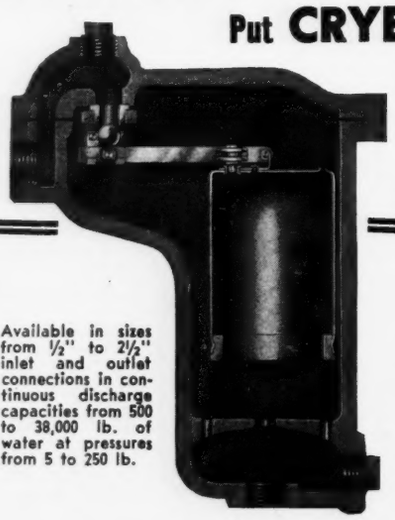
Anaconda Copper Tubes

THE AMERICAN BRASS COMPANY, General Offices: WATERBURY, CONNECTICUT

Offices and Agencies in Principal Cities • In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ont.

ELIMINATE YOUR TRAP TROUBLES

Put CRYER STEAM TRAPS



Available in sizes from ½" to 2½" inlet and outlet connections in continuous discharge capacities from 500 to 38,000 lb. of water at pressures from 5 to 250 lb.

on your lines . . . they're GUARANTEED to solve your problems

If you're troubled with air binding, dribbling, slow venting, unreliable drainage or too frequent maintenance of your steam traps—let CRYER show you how you can eliminate these headaches, save steam and step up steam line efficiency.

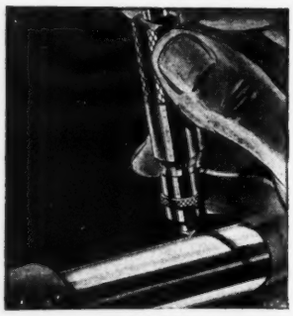
CRYER INVERTED BUCKET STEAM TRAPS are proving the solution to trap trouble problems in scores of plants because they are designed to operate properly under all conditions, insure mechanically controlled quick venting, are positive in action at all times and provide sufficient capacity to prevent sudden surges from interfering with normal operation.

Ask for Details on fast, positive-action, trouble-eliminating, accessible CRYER STEAM TRAPS. Find out why they quickly pay for themselves.

CRYER TRAP & VALVE CO., INC.

Manufacturers of Steam Specialties for more than 40 years.

366 Madison Ave., New York, N. Y.



JUDGE PACKING BY TIME AND A MICROMETER

PALMETTO for steam, air, hot fluids
PALCO for water
PELRO for solvents, oils
CUTNO for alkalis
SUPERCUTNO for acids

Any packing will prevent leakage for a time if you squeeze it in tightly enough. But how long will the packing last and how much will it wear the shaft? These are the all important factors that prove the superiority of Greene, Tweed Packings.

A TEST WILL CONVINCE YOU

Let us send you a free working sample. Compare the length of service it gives with any other packing. Measure the shaft before and after the test. That's how we sell Greene, Tweed Packing.

GREENE, TWEED SELF-LUBRICATING PACKINGS

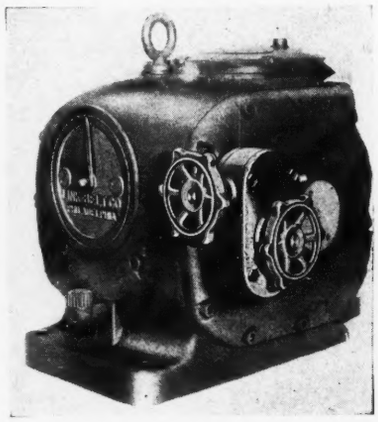
GREENE, TWEED & CO., 101 Park Ave., New York, N. Y.

110-, 220- or 240-volts polyphase ac circuits with 115, 230 or 550 volts, any amperage, output.

Cassels Engrg & Machine Co, P O Box 114, Wauwatosa, Wis.

Speed Control

VERNIER CONTROL can be supplied for all sizes of Link-Belt P I V gear variable-speed transmissions, where fine speed changes are required. Can be furnished with either one of two ratios: 7½ to 1 or 30 to 1, and is equipped with two hand

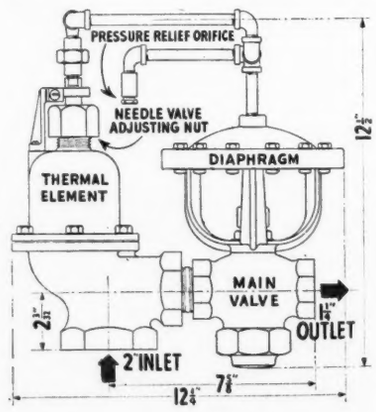


wheels. One is for direct control; secondary, or vernier-type control handwheel will provide either 30 or 7½ turns to one of the direct wheel, depending upon type reduction set selected.

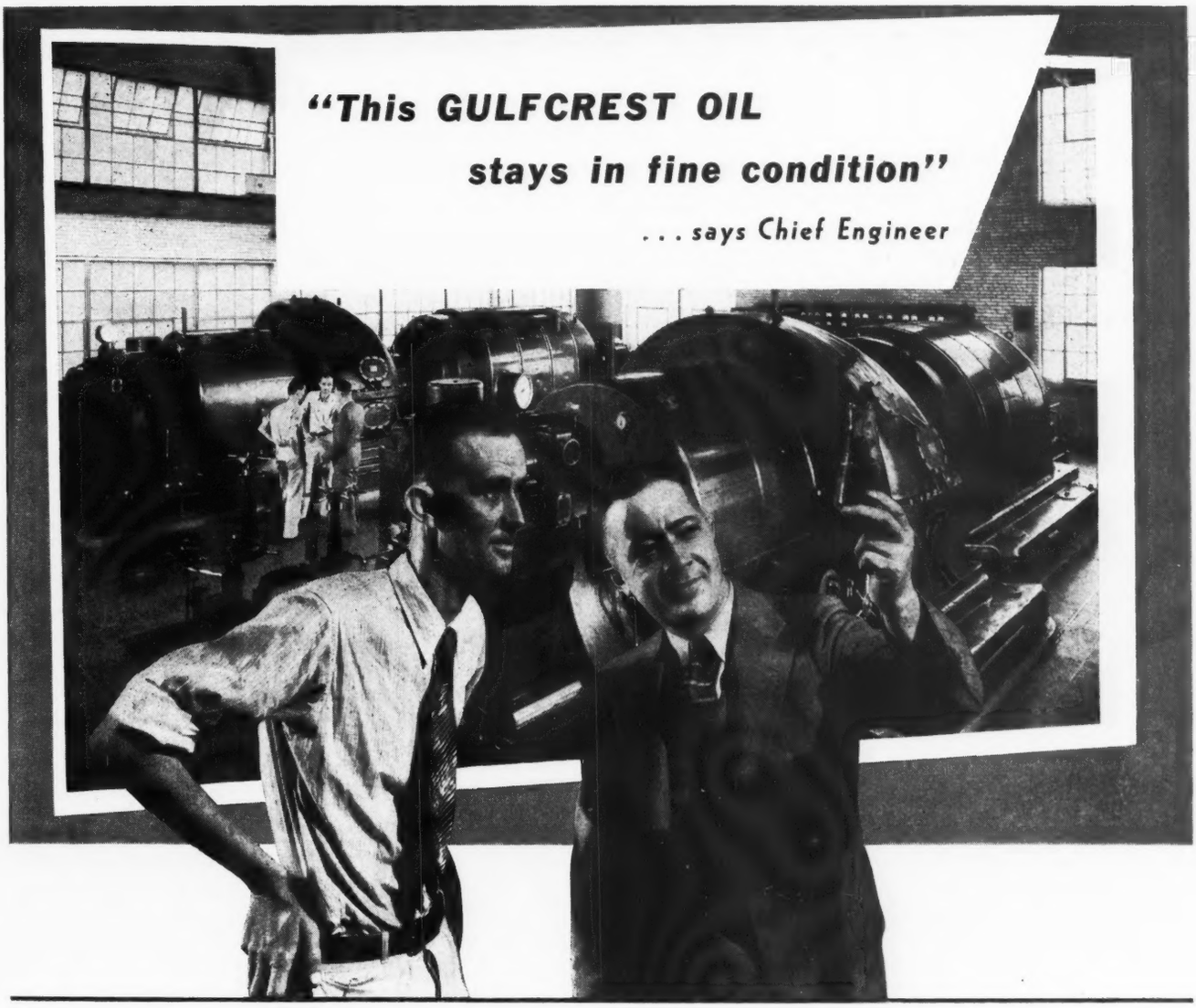
Link-Belt Co, 307 N Michigan Ave, Chicago, Ill.

Automatic Valve

AIR ELIMINATOR consists of conventional-type diaphragm valve, see cut, to which has been added special dome-shaped inlet chamber. Housed in dome of inlet chamber is bellows-type thermal expansion unit which raises and lowers a needle valve that seats against an orifice mounted in top of dome. This valve acts as pilot valve to admit pressure to top of diaphragm. Other pipe above diaphragm is fitted with small relief vent which dissipates pressure



above diaphragm when pilot valve is closed. Operation is automatic and is based on fact that air in a steam system has effect of lowering steam pressure and



"NO OPERATING TROUBLES with this stable Turbine Oil in Service . . . Very little Make-up Oil Required"

"WE ARE getting splendid results from the Gulfcrest Oil in our turbines," says this Chief Engineer to the Gulf lubrication engineer in the picture. "This higher quality oil has shown remarkable ability to retain its original characteristics without deterioration."

That's the kind of service you can expect from Gulfcrest Oil in *your* turbine units. Here is the reason for its remarkable stability: Gulfcrest Oil has been *especially refined and purified* by Gulf's Alchlor Process, the most effective method yet developed for removing undesirable hydrocarbons and other impurities which cause oxidation and sludge formation. Years of service in scores of turbine units from Maine to New Mexico have proved its marked superiority over turbine oils which have been formerly considered the best obtainable.

Ask the Gulf engineer who calls at your plant to give you the complete story of Gulfcrest Oil. This stable turbine lubricant—and more than 400 other oils and greases in the Gulf line—is quickly available to you through 1100 Gulf warehouses located at principal distributing points.

GULF OIL CORPORATION · GULF REFINING COMPANY
GULF BUILDING, PITTSBURGH, PENNSYLVANIA

GULF INDUSTRIAL LUBRICATION

ALSO A COMPLETE LINE OF FUEL AND FURNACE OILS

The Only Mechanical CO_2 INDICATOR

Product of Permutit

RAISE combustion efficiency, cut fuel costs, with the Ranarex CO_2 Indicator and Recorder. It shows at a glance the amount of CO_2 in flue gas. Works so fast you can open the fire-door and watch the needle drop. And you get a continuous record from the 24-hour chart.

MECHANICAL! No chemicals, orifices or fragile parts! Not affected by atmospheric changes. Easily taken apart with a screwdriver. Operates on lighting circuit. Portable models also available. Write for catalog: The Permutit Company, Dept. A, 330 West 42nd St., New York.

RANAREX

MECHANICAL CO_2 INDICATOR AND RECORDER

temperature. Mixture of air and steam entering 2-in. inlet cools thermal unit, which contracts, and opens needle valve. This in turn applies pressure to diaphragm, which is depressed, thus opening main valve and permitting the steam-air mixture to escape through a 1¼-in. outlet. When air has been exhausted, steam envelops thermal element, causing it to expand and close needle valve. With pressure relieved above diaphragm, internal pressure forces main valve to close. Sensitivity of air eliminator can be adjusted by means of needle-valve regulating nut, and unit is self-compensating for changes in steam pressure.

Armstrong Machine Works, 812 Maple St, Three Rivers, Mich.

Temperature Indicators

TEMPILS are pellets, stamped with an identifying temperature, which melt or liquefy when that temperature has been reached. In operation, pellets are placed upon or against heated object. When pellet melts, heated object has reached the temperature stated on the Tempil. They are available in hundred-degree ranges of 200, 300, 400 F, etc, and on request may be obtained in 50-deg intervals. Manufacturer claims safety in use. Says they are not corrosive to metals, and do not leave pits or objectionable stains which cannot easily be removed.

Tempil Corp, 132 West 22nd St, New York, N. Y.

Voltage Regulator

ROCKING-contact voltage-regulator is designed for control of small ac and dc generators. Unit has no vibrating contacts, tubes or other parts requiring replacement or readjustment at frequent intervals. Consists of sensitive solenoid-actuated plunger which acts on a main shaft, rocking a special contact sector over inner surface of a commutator, segments of which are permanently connected to regulating resistance. Segments are silver-plated to insure positive contact and are insulated.

Allis-Chalmers Mfg Co, Milwaukee, Wis.

Remote Control

SINGLE, right-angle, mechanical-remote-control for U. S. Varidrive motors said to provide accurate, simple means of select-

PROVE IT FIRST!

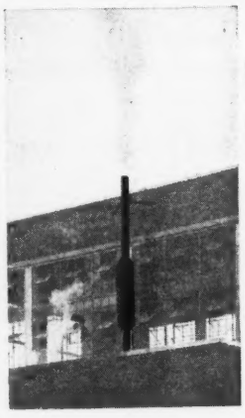
"The Entirely Different Boiler and Engine Treatment"

Try Sand-Banum in your own equipment for 30, 60 or 90 days. If it doesn't prove to be the most efficient method of eliminating scale and corrosion in boilers and engines—YOU PAY US NOTHING!

It comes in 16-oz. cans—*ready to use.* You can hold a month's supply for a 250 Hp. boiler in the palm of your hand!

AMERICAN SAND-BANUM CO., Inc.
9 Rockefeller Plaza
New York City

SILENT



yet . . .
15,800 lbs.
waste steam
per hour
passes
through

this MAXIM SILENCER

Do you have a problem of silencing waste steam discharge or boiler blow-off? We have quickly and easily solved this for many manufacturers with our Model BR9 —Write us today for information on this steam silencer, and on other Maxim Silencers for Engines and Compressors.

THE MAXIM SILENCER COMPANY

Hartford, Conn. New York, N. Y.

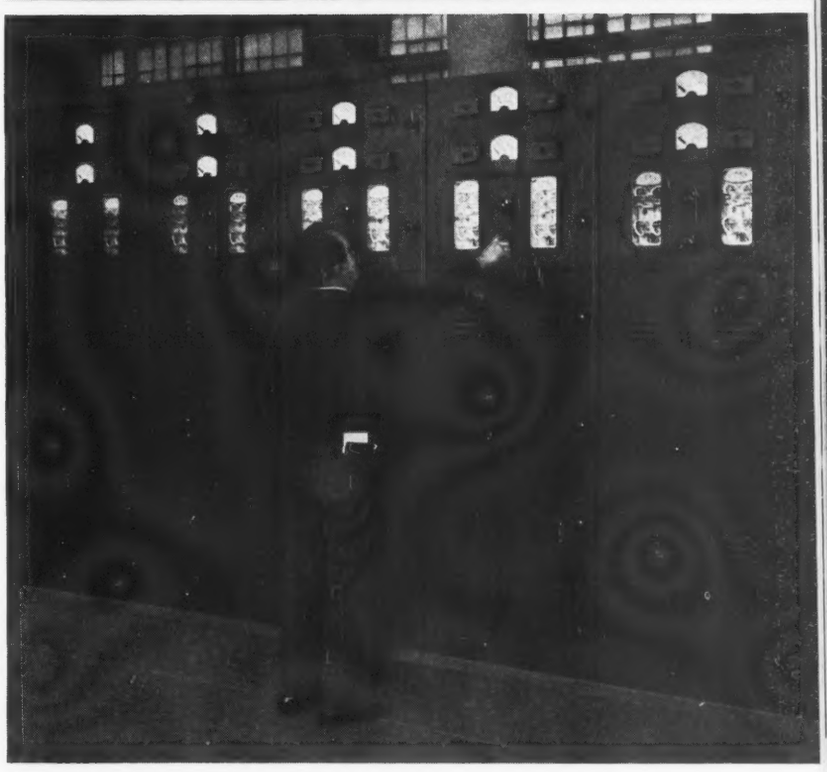
HE REALIZES THE IMPORTANCE OF "IC"

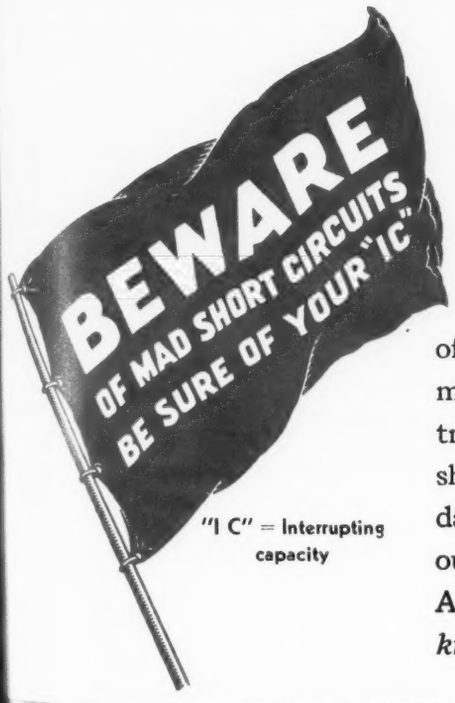
That's Why He's Installing G-E Air Circuit Breakers on All Branch Circuits

BESIDES adequate interrupting capacity ("I C"), G-E air circuit breakers provide overcurrent protection, with adjustable time delay. And you can restore service at once, safely, just by turning a handle. By providing three-phase interruption, single-phasing of motors, with all its harmful effects, is prevented. Because of their trip-free action, these circuit breakers cannot be held closed against short circuits. They are designed for interrupting ratings up to 80,000 amp.

For Main Circuits He Bought G-E Air Circuit Breakers Assembled as a Completely Enclosed Switchboard

This assembly of G-E air circuit breakers is installed as a unit. All you need do is to connect the leads. Being completely dead-front, it offers the advantage of safety over old-fashioned boards that have exposed live parts.





THE severity of a short circuit depends largely on the capacity of the transformers that feed the circuits and it can *not* be determined by the normal load on the circuit. As plant loads have grown, transformer capacities have been materially increased. Therefore, short circuits present an ever-increasing hazard. They gravely endanger personnel and property wherever the power supply has outgrown the interrupting capacity ("I C") of the protective devices. Are you sure of your "I C"? With G-E air circuit breakers of *known* interrupting capacity, you *can* be sure.

GENERAL ELECTRIC

890-80

ADVERTISING PAGES REMOVED

ROTO Offers a Faster, Cheaper and Better Way to Clean Tubes

THE introduction of the Rapid Action Roto Tube Cleaner made the old type tube cleaner as obsolete as a car without a self-starter.

Instead of needing two men per tube cleaner as before, the Roto, with its rapid action air valve, enables one man to operate the cleaner entirely by himself. The saving of time, which was formerly wasted in signalling the helper at a remote air valve between every one of the hundreds of tubes cleaned, now makes it possible to put the boiler back on the line hours sooner.

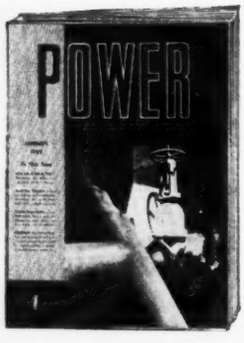
The new Roto motors develop unbelievable speed and power through a new design which makes more effective use of air consumed, without developing back pressure. Rugged, self-feeding cage and swing frame heads, universal joints and drills are available for the business end of the tube cleaner. There is a Roto cleaner for every size and shape of tube.

Put one of these new Rapid Action Roto Tube Cleaners to work in your plant, and you'll see why it comes out on top in competitive tests so consistently.

Model 135 Air-driven Motor with self-feeding cage-type head, and air valve for one-man operation.

Rapid Action Air Valve
Permits One-man Operation

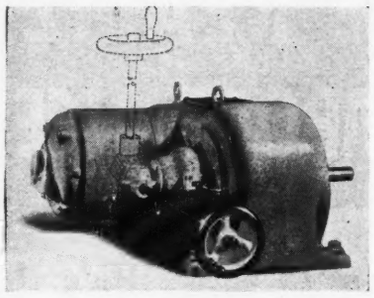
SEE OUR ADV. IN SWEET'S AND WRITE
The **ROTO** Company
145 Sussex Ave. Newark, N. J.



COMING — JUNE

Vital engineering data on 400 diesel and gas-engine plants installed since April 1, 1939.

WATCH FOR IT!

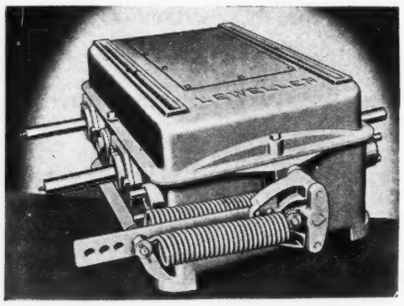


ing desired operating speed when motor is mounted above or below driven machine, or is otherwise hard to reach. Control can be extended in any one of eight different directions at 90 deg, and is operated by enclosed set of helical right-angle gears.

U. S. Electrical Motors, Inc, 200 E Slauson Ave, Los Angeles, Calif.

Stoker-Drive Speed Transmission

LEWELLEN transmission regulates stoker speeds for feeding fuel at rates to maintain automatically boiler pressure setting. Control attached to boiler is set for any desired steam pressure. Slight deviation from this pressure will result in movement of control connected to safety lever on transmission. While lever follows any



rapid motion of controlling device, speeds are adjusted only at safe rate of acceleration. Should lever move suddenly, it places a tension on springs, which in turn move shifting mechanism in transmission to increase or decrease gradually speed of variable shaft. When boiler pressure returns to preset figure, safety lever has reset for operating position. Speed to which transmission has been changed is maintained until another change takes place in boiler pressure.

Lewellen Mfg Co, Maple Ave, Columbus, Ind.

Luminous-Tube Transformer

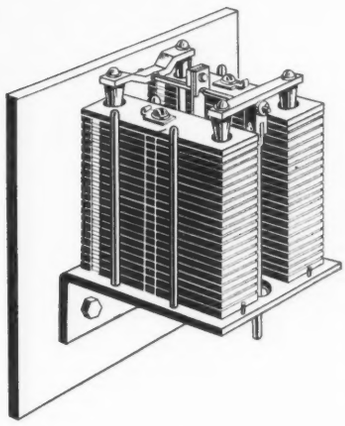
STREAMLINER transformer available in secondary ratings from 6000 to 15,000 volts. Features include high-voltage bushings, which are water-tight and free from internal corona, and new insulating compound, which is said to have higher dielectric strength, high heat conductivity, and high flow point. All porcelains are gasketed and leaded to case, and entire

(Continued on page 160)

NEW SMALL DIACTOR REGULATOR

For $70 List

Brings dependable voltage regulation to the small machine



All Diactor regulators have this type of fast, smooth-action rheostatic element—the only element that provides an infinite number of smooth resistance steps from practically zero to the maximum.

YES, there's a new small Diactor regulator in this outstanding line of General Electric generator-voltage regulators. It's the new Type GDA-29 for use with a-c generators, 31.3 kva and smaller, having self-excited exciters. Now you can equip machines in this size class with Diactor regulators built specially to do this job—at a cost that takes dependable voltage regulation for these small generators out of the luxury class.

Is a Full-fledged Regulator

This small regulator is the same as other Diactor regulator models in every way except size. It has the same quick-action, wide-range rheostatic element—the only element that provides an infinite number of smooth resistance steps from practically zero to the maximum. And the regulation curve obtained with it is correspondingly smooth. The enclosing case prevents the entrance of dust and dirt and gives the regulator a smooth, streamline appearance.

A Complete Line—Six Ratings

G-E Diactor regulators are available in six different ratings—for generators rated 18,750 kva at 3600 rpm, and smaller machines at correspondingly lower speeds. This complete line makes it easy for you to select regulators in correct ratings to meet your needs. A specialist in the nearest General Electric office can give you detailed information. Or use the coupon below to obtain Bulletin GEA-2022C. General Electric, Schenectady, N. Y.

General Electric Co., Dept. M-630-17
Schenectady, N. Y.

Please send me a complete description of the new line of Diactor generator-voltage regulators. (GEA-2022C)

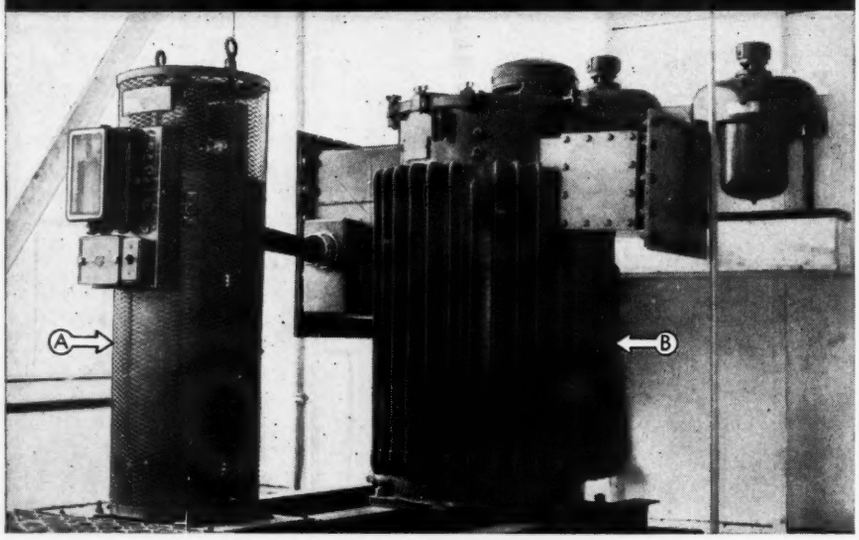
Name .....

Company .....

Address 630-17

GENERAL ELECTRIC

Now A G-E "REGULATOR" TO GIVE YOU BETTER LIGHTING —BETTER MOTOR PERFORMANCE



This G-E air-cooled regulator (A) in a modern factory provides precise voltage control for the lamps supplied by Pyranol transformer (B)

You know that voltage delivered at the correct level at your service entrance may fluctuate widely on your plant circuits because of varying power loads and lighting loads. You also know the advantages—in higher efficiency and increased production—of maintaining correct voltage on these circuits.

Now you can do it—economically—with the new G-E air-cooled Type AIRS regulators. They give a smooth, precise automatic voltage regulation that means better lighting, better motor performance, and better service from other electric equipment.

They are easily installed. Because they are air cooled, they require no expensive fireproof vaults. They take little space, and can be placed in out-of-the-way locations, even on beams up near the ceiling. Available in ratings from 1.2 to 12 kva, for 120-, 240-, 480-, and 600-volt circuits, and 10 per cent raise and 10 per cent lower regulation.

Find out for yourself how little these regulators cost. Ask your G-E representative for details, or write for Bulletin GEA-3057. Address General Electric, Schenectady, N. Y.

And for Testing—the Voltage You Want When You Want It

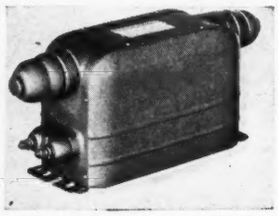
In many laboratory tests, precise voltage control is a major factor in accuracy of results. The new hand- and motor-operated Type AIRS regulators are available for a range of 100 per cent raise and 100 per cent lower, and give the exact voltage you require—at a turn of a crank, or of a switch. Complete description in GEA-3057.

GENERAL ELECTRIC

404-1

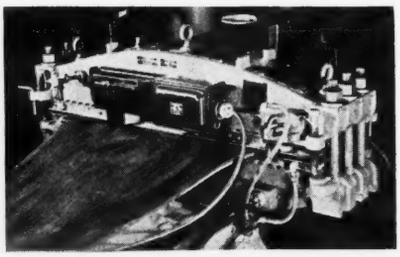
transformer may be lifted by bushings without danger from loose or broken connections. Grounding terminal provided at one end of case may be used to insure positive ground.

General Electric Co, Schenectady, N. Y.



Belt Vulcanizer

No. 36-42 VULCANIZER, made by J C Heintz Co for B F Goodrich, has platen 12 in. wide and long enough to span a 36-in. belt when vulcanizer is clamped on belt at approximately 22½-deg angle. Unit is plugged in circuit similar to any ap-



pliance, and comes equipped with thermostats for maintaining proper vulcanizing temperature. Current is turned on and off with variations of only 1 deg, while adjusting screw on control case permits adjustment to any temperature from 220 to 315 F.

B F Goodrich Co, 460 S Main St, Akron, Ohio

Slide-Rule Pipe Selector

SLIDE-RULE selector gives conservative answers to problems dealing with selection of pipe sizes for steam and water services. Uses pressure-drop method of determining pipe size instead of velocity, and complete instructions are included with selector, which comes with leather case.

J O Ross Engrg Co, 350 Madison Ave, New York, N. Y.

Wires & Cables

DILEC wires and cables are made with new-type fibrous covering composed of series of cotton yarns laid side by side in contact relation, overlaid by a rayon binder thread. New wires said to have all flame-retarding and moisture-resisting qualities found in other wires made by company, plus new type fibrous covering. Trade name, maker's name, type, size, and voltage and voltage of conductor are stamped on smooth covering, together with marker every two feet to facilitate measuring.

National Electric Products Corp, Pittsburgh, Pa.

DON'T FORGET *to Remember*

the big thing in Condenser Tubes—is

the name REVERE

BY PRESCRIPTION
℞ Choice of eleven different alloy compositions to meet your special operating conditions.
HOMOGENIZED
SKIN STRIPPED
CORE EXTRUDED
Tubes are produced by extrusion followed by cold working. The extrusion operation provides clean, dense, sound metal free from defects and impurities.
PRECISION PROVED
Rigid inspection at every step of production maintains Revere condenser tubes in conformity with rigid mechanical, metallurgical and chemical specifications.
RIGHT NEXT DOOR
Six Revere mills and coast to coast sales offices give you rapid, personalized service.

REVERE CONDENSER TUBES

REVERE COPPER AND BRASS INCORPORATED • 230 PARK AVE. • NEW YORK, N. Y.

MILLS: BALTIMORE, MD. • CHICAGO, ILL. • DETROIT, MICH. • NEW BEDFORD, MASS. • ROME, N.Y. • TAUNTON, MASS.

Here's a Profit Tip--

Put G-E PYRANOL Transformers at Load Centers

-- for Savings Like These

1. "We saved $500 on installed cost by using a Pyranol transformer to supply a lighting load," says R. H. Lewis, electrical superintendent of the Motor Wheel Corporation, Lansing, Michigan. This saving was possible because a fire-proof enclosing vault—which would have been required with an oil-filled transformer—was unnecessary, and because floor space was saved by mounting the Pyranol transformer on an overhead platform. By placing the transformer right at the load center, the cost of running a heavy three-wire secondary for 500 feet was also avoided.

2. The Byron Jackson Company, Los Angeles, installed a bank of three 200-kva Pyranol transformers in space that could not be used for production. The non-inflammable feature of Pyranol enabled this company to save the cost of building in the production area of the plant, an underground vault, which would have been required with oil-filled transformers.

3. Putting a Pyranol transformer at the load center cut feeder costs 50 per cent on a lighting circuit in the new recreation building of an Alabama cotton mill.

Find out for yourself how you can save on power- or lighting-circuit installations by installing G-E Pyranol transformers indoors at load centers. After installation you will get daily dividends in the form of reduced copper losses, better voltage regulation. Ask your G-E representative for complete information, or write today for Bulletin GEA-2637. Address General Electric, Schenectady, N.Y.

GENERAL ELECTRIC

402-4

Power Lines

(*Continued from page 128*)

BALTIMORE AREA:

Frederick Gardner Cottrell
Washington, D. C.

Gustave Fast
Fast Bearing Co

A L Penniman
Cons Gas, Electric Light & Power Co

F E Rickets
Cons Gas, Electric Light & Power Co

P L Betz

S Karrer
Cons Gas, Electric Light & Power Co

BOSTON AREA:

Roger W Andrews
Riley Stoker Corp

John H Ashbaugh
Westinghouse Elect & Mfg Co

Harold E Edgerton
Mass. Institute of Technology

Harold Frederick Hagen
B F Sturtevant Co

Albert J Loepsinger
Grinnell Co

Clesson E Mason
Foxboro Co

Henry E Warren
Warren Telechron Co

Edward R Wolfert
Westinghouse Elect & Mfg Co

CHICAGO AREA:

James D Cunningham
Republic Flow Meters Co

Harry H Barber
Barber-Greene Co

Lewis Martin Ellison
Ellison Draft Gage Co

Alfred L Eustice
Economy Fuse & Mfg Co

John Mayer Frank
ILG Electric Ventilating Co

Walter Geist
Allis-Chalmers Mfg Co

Joseph Harrington
Harrington Heater Co

Harry E La Bour
La Bour Co, Inc

Ira E McCabe
Mercoid Co

Martin L Nelson
Associated Electric Labs, Inc

Ray C Newhouse
Allis-Chalmers Mfg Co

Herbert F Obergfell
Associated Electric Labs, Inc

L R Smith
A O Smith Corp

William Halvor Taylor
Vilter Mfg Co

William M White
Allis-Chalmers Mfg Co

John Wicks
Associated Electric Labs, Inc

THE *Small* COMPANY WITH A *Big* RISK
" *Big* COMPANY WITH A *Small* RISK
" *Small* COMPANY WITH A *Small* RISK
" *Big* COMPANY WITH A *Big* RISK

You get and pay for only the protection you need under an "Ocean and Columbia" Power Plant Policy. No more, no less! Large company or small, big risk or little . . the only economically sound basis for buying boiler and machinery insurance is to have exactly the right amount of it. TOO MUCH doesn't give you more than you need . . . but it costs you more. TOO LITTLE can be disastrous and cost you EVEN MORE!

"Ocean and Columbia" have a specially trained staff whose job is to eliminate guesswork in shaping your protection. Accurate analysis and long experience combine to suggest a program based on fact and need. Luxury trimmings are not considered because to "Ocean and Columbia" this is a partnership job.

When the effects of operating failure have been measured . . when you are protected by the intelligent application of insurance principles . . then "Ocean and Columbia" engineers start the job of preventing accidents. . . A check-book may protect your investment but it can never compensate for the destruction of human lives, the loss of carefully built good-will and the heartaches of rebuilding a cherished business. The serious view which "Ocean and Columbia" engineers take of their responsibility to American Industry is proved by an impressive national record of accident frequency reduction.

Expert, common sense analysis of the boiler and machinery exposures in *your* plant . . . regardless of its size . . . is yours without obligation.

THE OCEAN ACCIDENT AND GUARANTEE CORPORATION, LIMITED

COLUMBIA CASUALTY COMPANY

THE OCEAN ACCIDENT & GUARANTEE CORPORATION
COLUMBIA CASUALTY COMPANY

One Park Avenue, New York, N. Y.

Pacific Department: 315 Montgomery Street, San Francisco, California
Canadian Branch: The Ocean Accident & Guarantee Corp., Ltd., Federal Building, Toronto, Ontario
Cuban Correspondent: Compania Cubana de Fianzas, Amargura 23, Havana, Cuba

$AVE WITH LOW COST EXACT CONTROL

For the many simpler control jobs which require instrument accuracy but do not warrant expensive instrumentation Mason-Neilan offers these low-cost controllers for pressures up to 600 lbs.

$ $ $ $ $

Though so compact that they may be mounted right on the control valve as well as on wall or panel, there is nothing "cheap" about these controllers. On the contrary they offer you more for your money than any other instrument in their price class.

$ $ $ $ $

They are fully indicating, have 1 to 30% throttling range, reversible operation and micrometer setting. Thousands are repaying their low cost many times over on reducing stations, pumps, desuperheaters, water lines and other services requiring exact pressure control.

Write for Catalog and Prices.

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1186 ADAMS ST., BOSTON, MASS., U. S. A.

New York Buffalo Philadelphia Pittsburgh Tulsa Toledo Chicago St. Louis Houston Los Angeles
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Thomas Randolph Harrison
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General Refractories Co

Francis Hodgkinson
Westinghouse Electric & Mfg Co

New chain DEFIES WEAR...

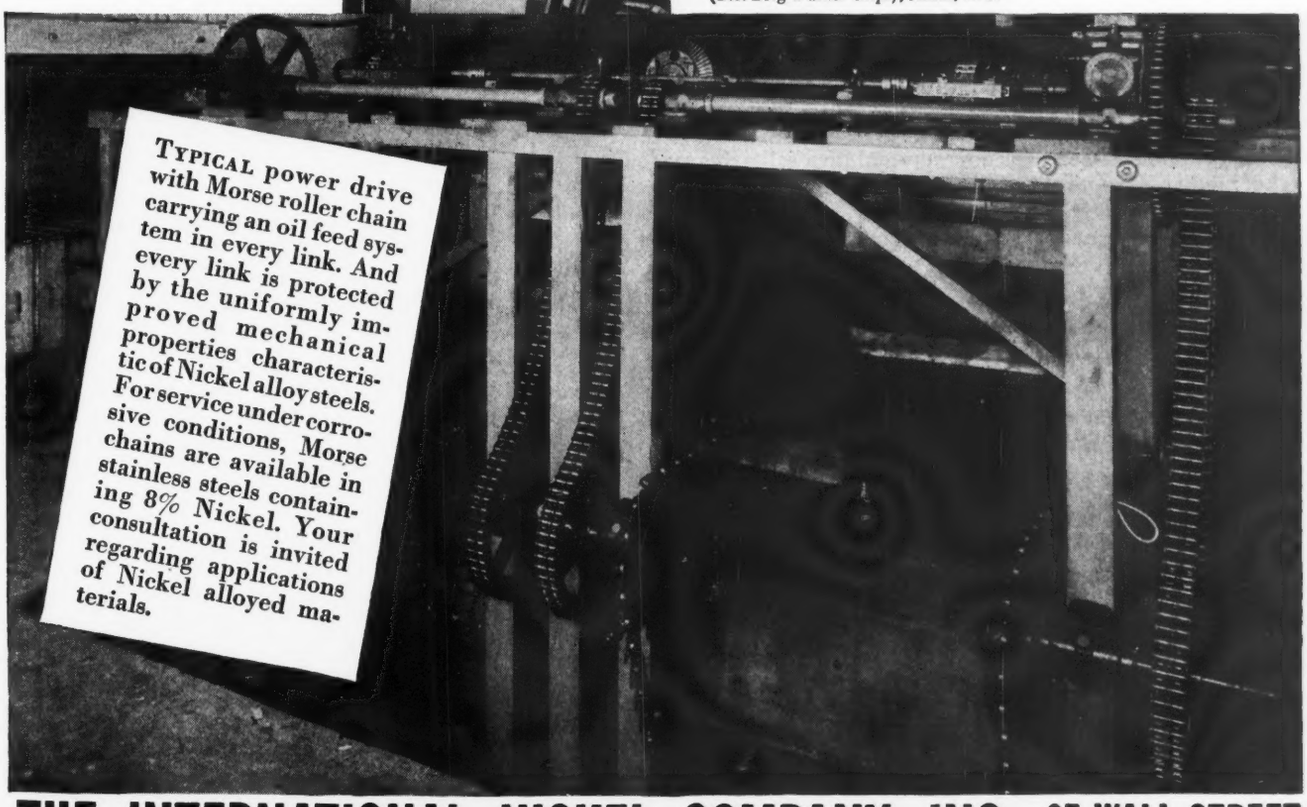
...with lubrication and long-lived

Nickel ALLOY STEELS

PINS and bushings oiled full length...side-plates oiled by the same spiral channels. There's the lubrication secret of these new Morse roller chains. But there's no secret about their strength, toughness and long life. That money-saving stamina comes from using suitable Nickel alloy steels in nearly every stressed part.

CLOSEUP of new Morse roller chain with bushing cut away to show the lubricating spiral channels. Wear is minimized, operation is quieter and more efficient. Morse engineers specify SAE 4620 Nickel-molybdenum steel and SAE 2520, 5% Nickel steel for pins in the smaller and medium sizes, and SAE 2520 for the pins in the larger pitches. Nickel-chromium steels SAE 3115, 3140 and 3135 are used respectively for bushings, side-plates and rollers.

Photos courtesy Morse Chain Company (Div. Borg-Warner Corp.), Ithaca, N. Y.



TYPICAL power drive with Morse roller chain carrying an oil feed system in every link. And every link is protected by the uniformly improved mechanical properties characteristic of Nickel alloy steels. For service under corrosive conditions, Morse chains are available in stainless steels containing 8% Nickel. Your consultation is invited regarding applications of Nickel alloyed materials.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

This can of dirt was removed from a watch factory by a Spencer Vacuum System in a few hours. It contains oily sawdust, microscopic watch parts, glass, paper, lint and just plain dirt.

WHAT DOES A CAN OF DIRT A DAY COST YOU?

We mean the can of dirt you don't get—the part that is in cracks in the floors, in and under machinery, or stirred up with brooms to spread over your ceilings, walls, equipment and eventually the finished and unfinished goods.

You can figure the answer yourself. Just estimate roughly the annual worth of the following items:

A 25% saving in cost of cleaning floors .....
A 50% saving in cost of cleaning overhead .....
A 70% saving in cost of cleaning machinery .....
Saving due to reclaiming valuable materials .....
Saving by elimination of rejects due to dust .....
Value of reduced fire, explosion and health hazards .....
Saving in fuel by cleaning boiler tubes .....
Per Year Total $.....

The first three percentages are representative estimates made by present users of the Spencer Vacuum System. Spencer representatives will study your plant and make a specific estimate on request.

It Adds Up

It adds up to the fact that any one of these seven items may pay for a Spencer Vacuum System in two years. If you can save on two items there's a nice profit.

A survey of 444 users shows that most plants report savings on at least 3 items.

Compare what they are doing with Spencer Vacuum with present methods in your plant. The results are illustrated in the new Spencer Bulletin. Ask for Bulletin 120F.

150-C

SPENCER HARTFORD
CENTRAL AND PORTABLE VACUUM CLEANING SYSTEMS
THE SPENCER TURBINE COMPANY, HARTFORD, CONN.

Morris Evans Leeds
Leeds & Northrup Co
David Chandler Prince
General Electric Co
William K Rankin
General Electric Co
Henry Frederick Schmidt
Westinghouse Elect & Mfg Co

ROCHESTER AREA:

Willis Haviland Carrier
Carrier Corp
Albert A Criqui
Buffalo Forge Co
William Chauncey Geer
B F Goodrich Co

SAN FRANCISCO AREA:

William John Besler
Besler Systems

ST. LOUIS AREA:

Burns Dick
Wagner Electric Corp
Lowell Cleland Hewitt
Laclede-Christy Clay Products Co
William D Moore
American Cast Iron Pipe Co
Edwin S Pillsbury
Century Electric Co
Hans Weichsel
Wagner Electric Corp

GE Turbine Orders Since '39 Exceed 1,000,000-kw

Turbine-generators ordered from General Electric for U. S. utility and municipal power plants since January 1, 1939, in ratings of 10,000 kw and higher, exceeded the 1,000,000-kw mark in the 14 months ending February 29, according to announcement made by C S Coggeshall, manager of the Turbine Div.

An analysis of orders comprising this total indicates a definite trend to higher temperatures and pressures and use of hydrogen-cooling in power-generating equipment. In terms of kilowatts, 85% of total capacity ordered will use initial steam pressures of 800 lb and above, with more than 50% in the 1200-lb range. Similarly, 85% of the total will use initial steam temperatures of 900 F and above, 60% will be in the range of 900 to 925 F, while the other 25% will be 950 F and higher. Average capacity of hydrogen-cooled machines is 43,700 kw, as against 28,900 kw for air-cooled machines.

Lack of Natural Gas Forces Changes To Coal Burning

Because no additional source of natural gas in New York-Pennsylvania deep-test field can be discovered, three of Wellsville's, N. Y., leading industrials will return to the use of coal for power and heating.

The three companies, customers of the Empire Gas & Fuel Co, Ltd, Wellsville,

IT'S SCREENLESS!

-the new WATROUS SILENT-ACTION FLUSH VALVE

Tests made by a nationally known, independent research laboratory (name on request) show Watrous SILENT-ACTION equipment eliminates an average of 88.5% of flush valve noise energy.

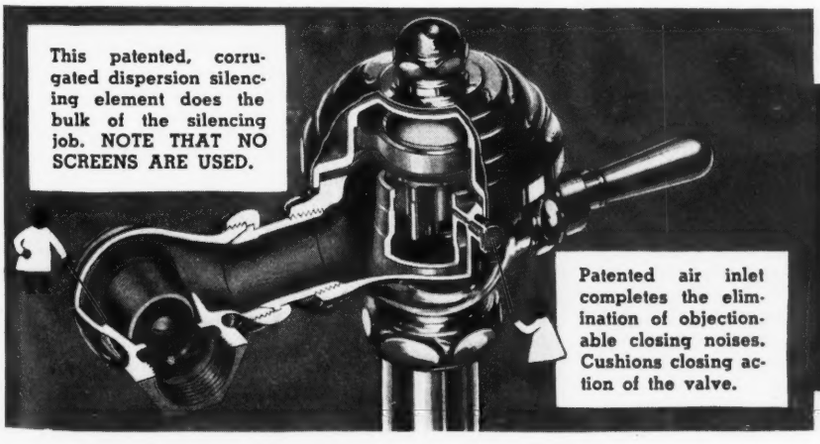
Here is a SILENT TYPE FLUSH VALVE THAT STAYS SILENT

YOU will find the new Watrous SILENT-ACTION Flush Valve distinguished in *two* ways: First, it operates with almost unbelievable silence (proved by independent laboratory tests). And second, alone among all silent-type flush valves, it has no screens, shot or mufflers of any type whatsoever to become clogged.

As a result, this valve brings to users 3 highly important advantages: (1) It assures silent operation that *STAYS* silent. (2) It eliminates the need for frequent adjustment of shut-off to compensate for gradual clogging (such as occurs when screens are employed). (3) It has no parts requiring frequent replacement or cleaning.

All Watrous Flush Valves can be furnished complete with Watrous SILENT-ACTION equipment. Equipment can also be used to eliminate the bulk of flush valve noise on old installations.

For complete information, write for your copy of "A Scientific Method of Silencing Flush Valves."



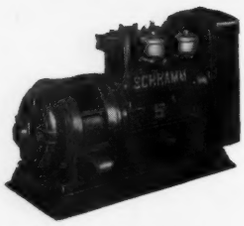
This patented, corrugated dispersion silencing element does the bulk of the silencing job. NOTE THAT NO SCREENS ARE USED.

Patented air inlet completes the elimination of objectionable closing noises. Cushions closing action of the valve.

THE IMPERIAL BRASS MFG. CO.
514 So. Racine Ave. Chicago, Ill.

Watrous SILENT-ACTION Flush Valves

SCHRAMM
AIR COMPRESSORS



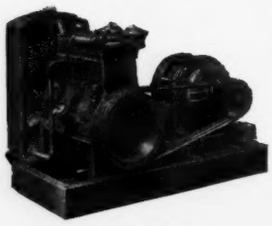
DIRECT MOTOR DRIVES

..make air power available quickly and cheaply

You can have compressed air power any place you need it, any time, easily and at low cost with SCHRAMM Stationary Air Compressors.

These units are modern in every detail of design and proven in service. They will save you money—in time, space, operation and maintenance. They require no foundation, can be installed in any convenient location, require a minimum of piping, and are available with or without motor or engine drive. Schramm offers complete accessory equipment including air receivers, cooling units, water and air valves, starting controls, after coolers and filters.

Our new 16-page engineering bulletin #3907 gives complete details and specifications. Write for your copy *Today!*



"V" BELT DRIVES

SCHRAMM, INC., WEST CHESTER, PA.
ESTABLISHED, 1900

A Wilson "Matched Unit"—An E P (Extra Power) Heavy Duty Air Motor and an F P T Cutter Head.

SAVE AIR, TIME AND MONEY AND DO A BETTER CLEANING JOB

The new Wilson E P (Extra Power) Series Heavy Duty Air Motors use from 25% to 40% *less air* and develop from 30% to 75% *more power* than ordinary tube cleaning motors of the same size. They also clean cleaner and faster and are therefore not only the most efficient but also the most economical air motors you can buy for removing very heavy or very hard deposits from tubes and pipes.

There is a Wilson tube cleaning motor and cutter head or other accessory especially suitable for cleaning any size or kind of cleanable tube or pipe from 5/8" O.D. to 20" I.D.

Send for our new thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
55 Vandam Street New York City

N. Y., are the Sinclair Refining Co, Moore Steam Turbine Div, and Air Preheater Corp. The Sinclair refinery has already changed over equipment to handle coal, and fuel oil-burning equipment has been installed for auxiliary or emergency use. Moore Steam Turbine Div is changing its equipment, and Air Preheater Corp has plans under way for installation of coal-burning equipment.

Decision to withdraw companies from the gas lines was described as a conservative measure "to insure an adequate supply of natural gas for the domestic consumer".

AIEE Nominates Officers

The national nominating committee of the American Institute of Electrical Engineers has nominated the following official ticket of candidates for offices becoming vacant August 1, 1940. These official candidates, together with any independent nominees that may be proposed later, will be voted upon by the membership at an election this spring:

For President: R W SORENSEN, California Institute of Technology, Pasadena, Calif.

For Vice-Presidents: (North Eastern District), EVERETT S LEE, General Electric Co, Schenectady, N. Y.; (New York City District), J W BARKER, Columbia University, New York, N. Y.; (Great Lakes District), K L HANSEN, Harnischfeger Corp, Milwaukee, Wis. (South West District), J L HAMILTON,

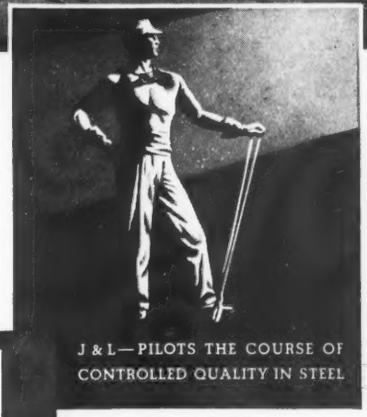
FIREMAN'S FIRST FIFTY

Jeremiah Flynn (left) fireman at the Dutch Point steam plant of the Hartford Electric Light Co, receives the first 50-year service medal ever awarded to an employee of this utility. President Samuel Ferguson (right) performed this pleasant duty on behalf of the management. It's a safe bet that Mr Flynn recalled the shovel era of 1885 in thinking about the present-day setting in which the boiler-house worker functions

YOU CAN DEPEND ON J&L SEAMLESS PIPE TO CARRY PRESSURE LOADS SAFELY AND EFFICIENTLY — AND TO GIVE YOU LOW MAINTENANCE COSTS • • •

specifying J&L Seamless for power piping, engineers and maintenance men throughout the ntry have endorsed it for strength, safety and dependability. Every length of J&L Seamless olled from a solid billet of "controlled quality" steel. There are no welds, therefore no chance ailure at or near a weld.

Scientific control of all J&L finishing operations assures uniform wall thickness, concentricity the right ductility for easy bending and upsetting. Therefore when J&L Seamless is specified, manufacture of joints and the installation of the pipe move along smoothly and efficiently. hundreds of plants J&L piping is giving completely satisfactory service. Spe- J&L Seamless for your power piping jobs. In the meantime, get helpful rmation on piping applications by writing for our Handbook SP-4.



J & L—PILOTS THE COURSE OF CONTROLLED QUALITY IN STEEL

ONES & LAUGHLIN STEEL CORPORATION

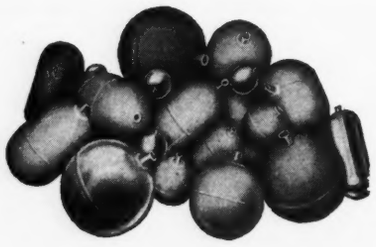
AMERICAN IRON AND STEEL WORKS
PITTSBURGH, PENNSYLVANIA

J&L STEEL

&L—PARTNER IN PROGRESS TO AMERICAN INDUSTRY

NICHOLSON

HIGH PRESSURE WELDED FLOATS—Stainless Steel-Chromium Plated Steel



Available for all applications—for steam pressures up to 1500 lbs. and hydrostatic pressures up to 2500 lbs.—for corrosive and non-corrosive service.

Made in spherical and elliptical shapes in sizes from 2½" to 14" diameter. High in tensile strength and offer great resistance to external pressure. Special sizes and shapes available to order, and also cadmium, nickel or copper plated. Fully described in Bulletin No. 339.

2-, 3- or 4-WAY CONTROL VALVES for SINGLE and DOUBLE ACTING CYLINDERS

Special types also available.

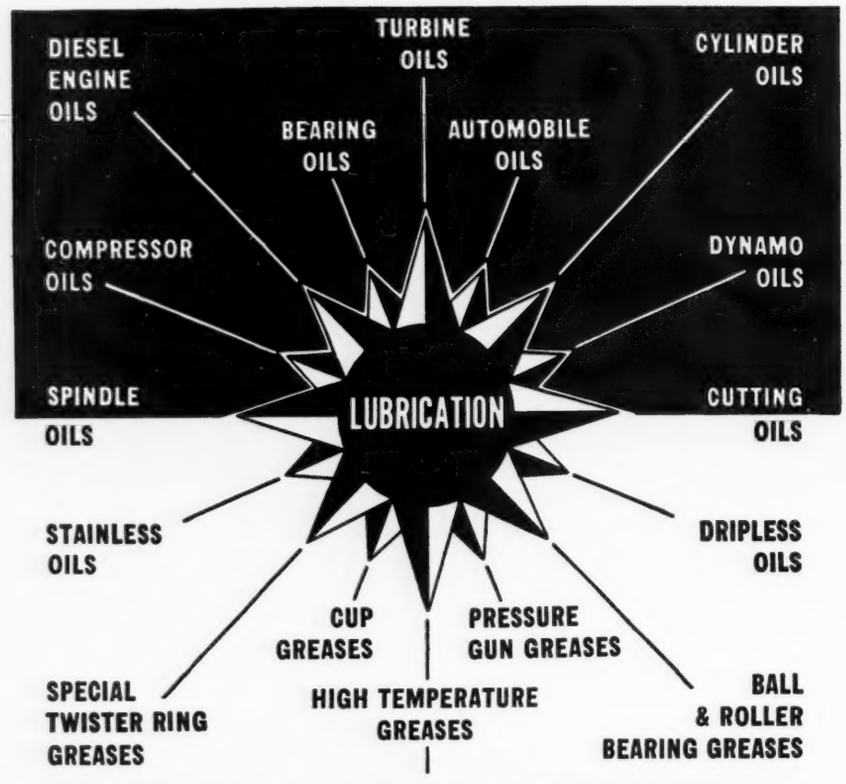
Designed for long life, quick and dependable control of air, steam, oil, gas or water on pressures up to 300 lbs.

Made also in foot, solenoid and motor operated types—also balanced valves for high pressure hydraulic service. Ask for Bulletin No. 933 for details.

OTHER PRODUCTS

NICHOLSON Industrial Steam Traps, Piston and Weight Operated Traps, Flexible Couplings, Expanding Mandrels, Arbor Presses, Compression Shaft Couplings, Steam Eliminators and Separators, Compressed Air Traps.

W. H. NICHOLSON & COMPANY
125 OREGON ST. WILKES-BARRE, PENNSYLVANIA, U. S. A.



PRODUCERS of HIGH GRADE LUBRICANTS SINCE 1874

BORNE SCRYMSER COMPANY
17 BATTERY PLACE • NEW YORK

Century Electric Co, St. Louis, Mo.; (North West District), A LeROY TAYLOR, University of Utah, Salt Lake City, Utah.

For Directors: T F BARTON, General Electric Co, New York, N. Y.; M S COOVER, Iowa State College, Ames, Iowa; R G WARNER, United Illuminating Co, New Haven, Conn.

For National Treasurer: W I SLICHTER, Columbia University, New York, N. Y.

Elliott Co Gets Rights To Buchi Superchargers

Elliott Co, Jeannette, Pa., has acquired from Dr Alfred J Buchi of Winterthur, Switzerland, a license to manufacture superchargers for use with patented Buchi supercharging systems, and in accordance with Buchi design patents. Field of application covered by license agreement includes 4-stroke-cycle internal-combustion engines for stationary, marine and traction purposes.

The superchargers, commonly called turbo-chargers, are small turbine-driven centrifugal blower units. They are used to scavenge and supercharge 4-stroke-cycle internal-combustion engines. The turbine is propelled by exhaust gases to obtain maximum efficiency from energy in the exhaust gas. Turbo-chargers employed in the Buchi system have been used on approximately 1000 engines, totalling 1,000,000 hp—mostly in Europe.

Glendale To Get First Outdoor Turbine-Generator

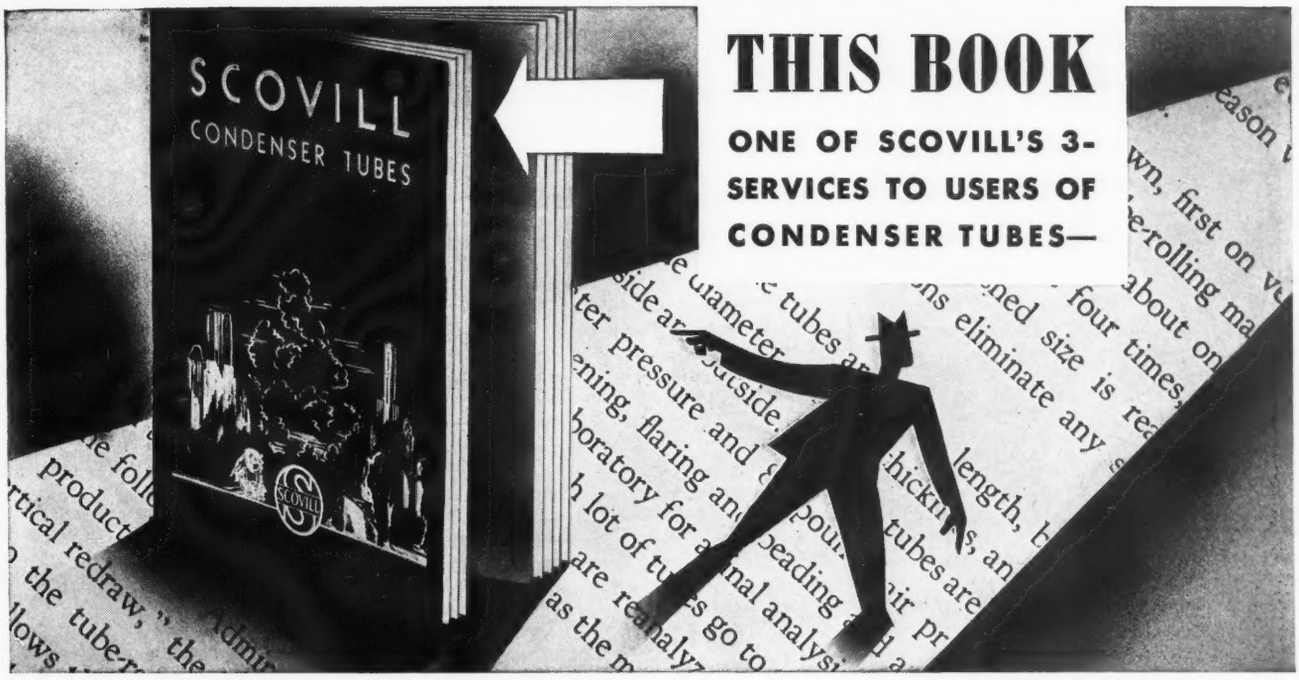
The City of Glendale, Calif., will install its first hydrogen-cooled turbine-generator for outdoor installation. The turbine-generator is being built by General Electric Co. New plant is said to cost less than conventional-type plants, because of the absence of heavy building structures. Boilers and firing aisle are to be enclosed with stucco-covered light-steel frame housing, and the turbine-generator will be upon an open deck and served with a traveling gantry crane.

Basically, the Glendale unit will be the same as a hydrogen-cooled turbine-generator built for conventional installation indoors, except for a welded-sheet-steel housing over the high-pressure end of turbine proper. Unit is hydrogen-tight and air-tight, making operation independent of weather conditions and changes.

Rated at 20,000 kw, 13,800 volts at 3600 rpm, the unit will operate at 0.8 pf and have total output of 25,000 kva. It will use steam at 600 lb g, with a back pressure of 2-in. mercury absolute.

Duke Power System Adds 80,000 Kw

Capacity of Duke Power Co's Buck Steam Station on Yadkin River near Salisbury, N. C., will be increased by 80,000 kw with installation of a hydrogen-cooled turbine-generator being built by General Electric Co. Unit, largest in the Duke



THIS BOOK

ONE OF SCOVILL'S 3-SERVICES TO USERS OF CONDENSER TUBES—

CAN SAVE YOU TIME AND MONEY

Enriched with new metal developments and the findings of our recent and varied experiences with condenser tubes—this new edition of Scovill's well-known "Condenser Tube Booklet" is both a preventer and a corrector of tube troubles.

SERVICE IN MANUALS

is what we call the publication of this literature, for it is available without charge to all users of condenser or heat exchanger tubes. If you haven't yet received this new "Condenser Tube Booklet," send us the coupon for your free copy.

SERVICE IN METALS

means that Scovill laboratories do twofold work for tube buyers. First, they develop alloys which will operate better under certain difficult conditions. Some of these are described in the booklet. Second, they are daily giving physical tests to raw materials, and also to finished tubes before shipment.

SERVICE IN MEN

is the third of Scovill's services. Engineering representatives help you in the first place to pick the alloy that will serve best under your particular conditions. Then if you ever *do* have trouble, they go to work diagnosing and removing the cause. For example — a Scovill tube user experienced rapid inlet end tube corrosion — but no exposed intake opening could be found. A check by Scovill engineers located the source of air—a combination of tide and plant construction. An inexpensive change eliminated the entrained air. Tube life was materially improved.

for any of these services . . .
***think of* SCOVILL, "MASTERS OF METAL"**

Scovill
MANUFACTURING COMPANY
WATERBURY, CONN.

SCOVILL CONDENSER TUBES
one product . . . three services

SCOVILL MANUFACTURING COMPANY
13 Mill Street, Waterbury, Connecticut

Please send me the new, revised "Condenser Tube Booklet."

Name.....

Company.....

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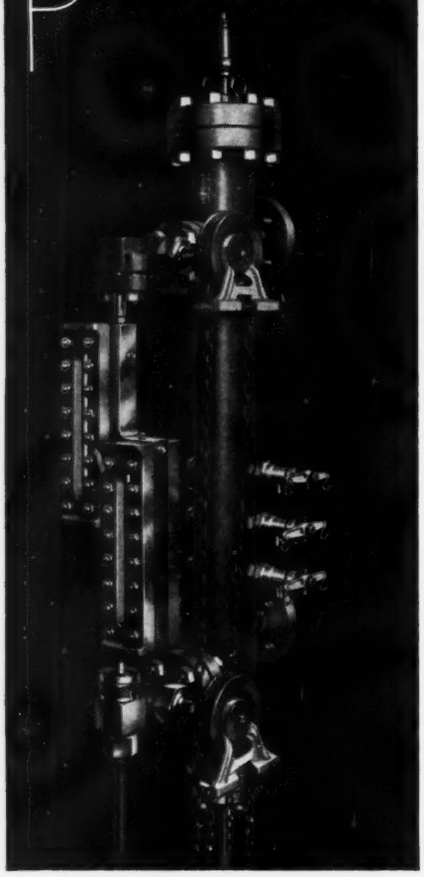
POSITIVE
Protection



Yarway's unique Hi-Lo Alarm mechanism utilizes balanced *solid weights* that are as indestructible and unchanging as the metal itself. Operating on the displacement principle, they literally "weigh the water level."

When the high or low water emergency occurs—instant, positive, powerful, hair-trigger *action* results—giving warning of danger by whistle, light, or both.

Yarway Water Columns, eight standard models, iron bodies with screwed connections for pressures up to 250 lbs., forged steel bodies with flanged connections for pressures up to 1500 lbs., are fully described in Catalog WG-1807. Write for a copy and working model.

YARNALL-WARING COMPANY
100 Mermaid Ave. Philadelphia

YARWAY
FLOATLESS HI-LO ALARM
WATER COLUMN

power system, will use 825 lb steam pressure at throttle, 900 F, and will operate at 1800 rpm. Present 70,000-kw generating capacity at Buck station is made up of two 35,000-kw G-E units, installed in 1926.

First Hydrogen-Cooled Unit Ordered for Edgewater Plant

Wisconsin Power & Light has placed an order for a hydrogen-cooled turbine-generator to be installed in the company's Edgewater plant, near Sheboygan, with the Allis-Chalmers Mfg Co. Although it is the first hydrogen-cooled unit at the plant, there is another 30,000-kw turbine-generator.

The new unit consists of a 30,000-kw tandem-compound steam turbine designed for 650 lb, 800 F, 29-in. vacuum. It will be direct-mounted to a 3600-rpm, 12,500-volt, hydrogen-cooled generator.

OBITUARIES

T S Perkins, formerly general manager of merchandising for Westinghouse Electric & Mfg Co until his retirement in 1933, died at Irwin, Pa., January 7. Born at Idlewood, Pa., he was graduated from Worcester Polytechnic Institute in 1893.

G F Elliott chairman of the board of directors, Elliott Co, Jeannette, Pa., died of pneumonia at Ridgway January 22, following a two week's illness. He studied at Cornell and Penn State Universities, being graduated from the latter in 1916. Following service in the Ordnance Dept, U. S. Army, he joined the Elliott Co. In 1926 he was made a vice-president of the company, and named manager of the Ridgway works. Upon the death of W S Elliott in 1935 he became president, and in 1937 was made chairman.

John J Fasmer, until recently general sales manager of Stephens-Adamson Mfg Co died on February 3. At 56 years of age, he had been in active service with the firm since its organization in 1901.

Walter Francis Keenan, Jr., 54, director and vice-president in charge of engineering of Foster Wheeler Corp, 165 Broadway, New York, N. Y., died at his home in Pelham Manor, N. Y. He had been associated with Foster Wheeler for 29 years, and was chief engineer for some time before he was elected a vice-president in 1935. He was president of the American Boiler Manufacturers Assn., and a member of the American Society of Mechanical Engineers. He was graduated from the University of Pennsylvania, and supervised the design and installation of several boilers for the U. S. Navy.

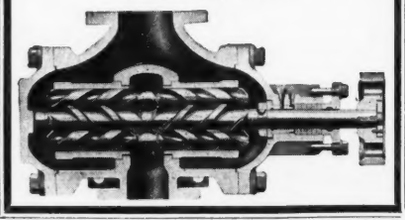
James J Quinn, 54, vice-president of American Furnace Co, St. Louis, Mo., died on February 26. He joined the company in 1903 and had been associated with it ever since.

Earl G Haupt, president of St. Louis Chapter, National Association of Power Engineers, died at the city hospital on February 25, following an automobile accident in which he suffered skull in-

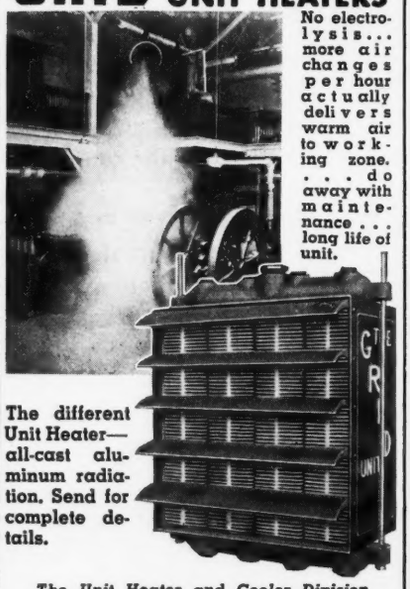
THE IMO test room has quantities of various oils and facilities for heating them to various temperatures, also dynamometers and other testing equipment, so that any IMO pump can be tested under the conditions for which it is sold, thereby assuring satisfactory operation in the user's plant.

Publication I-51 gives data on various IMO applications.

DE LAVAL STEAM TURBINE CO.
TRENTON, N. J.



YOU CAN DEPEND ON
GRID UNIT HEATERS



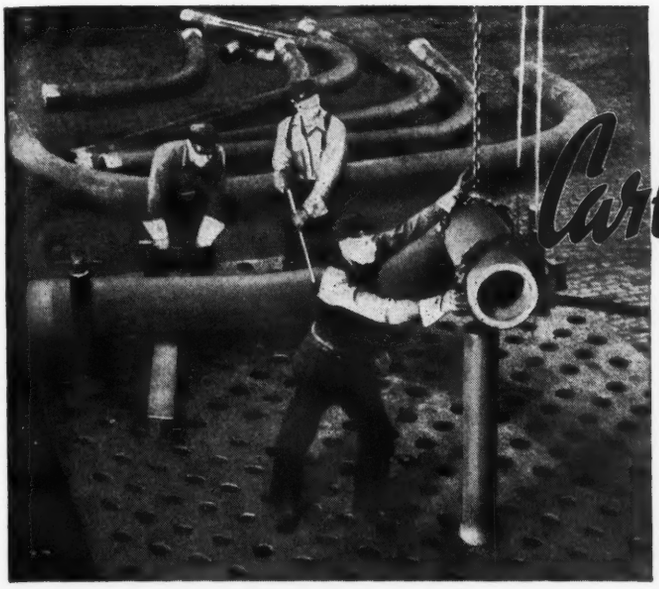
No electrolysis... more air changes per hour actually delivers warm air to working zone. . . . do away with maintenance . . . long life of unit.

The different Unit Heater—all-cast aluminum radiation. Send for complete details.

The Unit Heater and Cooler Division
D. J. MURRAY MFG. CO.
Wausau, Wisconsin
Offices in all principal cities

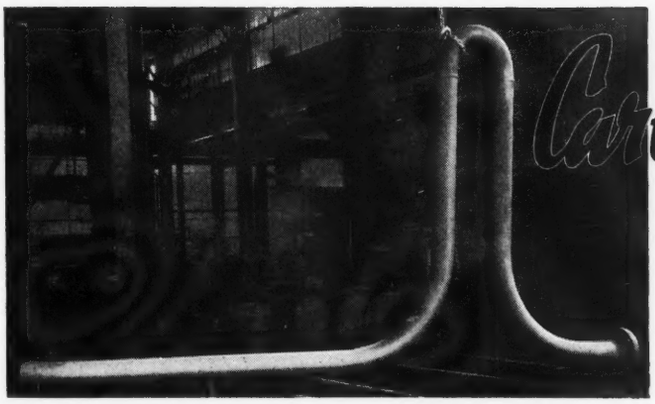
GRID
UNIT HEATER

PITTSBURGH PIPING CAN MEET
Your Piping Requirements to the Letter



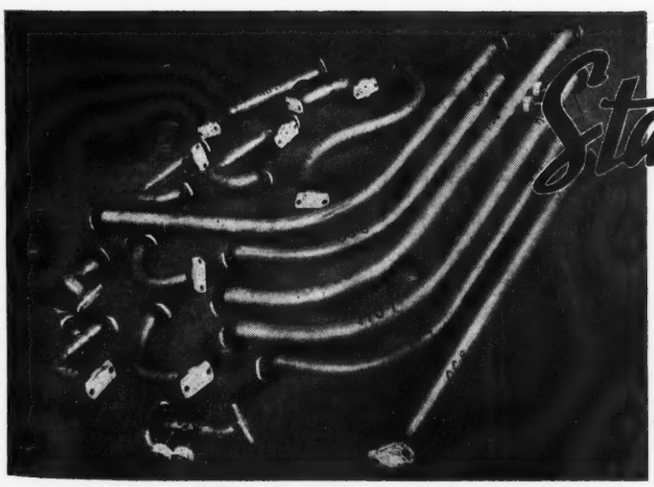
Carbon Moly Steel Piping

Since the increase in steam pressures and temperatures made the use of low alloy steels necessary, Pittsburgh Piping has fabricated and erected this type of piping for many of the country's foremost power systems. Because Carbon Molybdenum and other low alloy steels require extra care in fabrication, Pittsburgh Piping has developed a special technique for the highly efficient working of this type of material. This special technique extends to all operations in field erection as well.



Carbon Steel Piping

In its five acre plant, Pittsburgh Piping has complete facilities for pre-fabricating large sub-assemblies for every conceivable power and process requirement. Modern erection equipment and field welding methods used by specially trained crews assure speedy and efficient erection without interfering with other sub-contractors on the job.



Stainless Steel Piping

Since 1933, the Alloy Division of Pittsburgh Piping has been fabricating stainless piping and vessels for process industries. Because of the many metallurgical characteristics peculiar to stainless steel alone, Pittsburgh Piping has experienced fabricators that work only on stainless. The relative high cost of raw materials makes it more imperative than ever to have this type of fabrication done by stainless specialists at Pittsburgh Piping.

PITTSBURGH PIPING & EQUIPMENT CO., 10 FORTY-THIRD ST., PITTSBURGH, PA.

Woolworth Bldg. New York | Occidental Bldg. Indianapolis | Peoples Gas Bldg. Chicago | General Motors Bldg. Detroit | Public Sq. Bldg. Cleveland | 10 High St. Boston | 1st. Nat'l. Bank Bldg. Charlotte | 525 Market St. San Francisco

Pittsburgh Piping

Make your REFRIGERATION DOLLARS put on overalls
The No. 243 Purger shown at the right has been used successfully on systems ranging in size from 12 tons up to 800 tons capacity. List price, $100.
This New "AIR ELIMINATOR" helps maintain PEAK EFFICIENCY

Removes Air from Refrigerating Systems . . . Lowers Working Pressures . . . Cuts Power Costs . . . Increases Efficiency!

MAKE the dollars you spend for refrigeration get into their work clothes and really deliver! This new Armstrong Purger will help you do it. Although only recently introduced, the Armstrong Purger has already earned a nation-wide reputation for cutting power costs!

Rapidly gaining attention as one of the outstanding developments in refrigeration engineering, the new Purger automatically and continuously purges air and other non-condensable gases as they work down from the condensing coils. This lowers high side pressures and reduces power costs—an average of 2% for each 4-pound pressure reduction!

Furthermore, the removal of inert air with its insulating effect increases the capacity of the condensing coils—often an additional saving of considerable significance. The refrigerant lost with the air expelled is negligible — in striking contrast with the large amounts wasted with obsolete "blow-down" methods. Let us show you how to save dollars often wasted in pumping dead air around the system, or spent in frequent and unnecessary recharging! Write for complete information about this outstanding "Air Eliminator" TODAY! ARMSTRONG MACHINE WORKS, 812 Maple Street, Three Rivers, Michigan.

The ARMSTRONG PURGER

juries. Mr Haupt, 35, was assistant chief engineer at the Deaconess Hospital.

DEWITT PAGE, 70, formerly president and general manager of New Departure Div, General Motors Co, Harrison, N. J., and director and vice-president of General Motors Corp, died at Hialeah Park, Florida on February 28.

DAVID C JONES, 63, vice-president and general manager, Lunkenheimer Co, died at Christ Hospital, Cincinnati, Ohio, on March 11. He had been in good health until a week before his death, when he was taken to the hospital for an emergency operation. He joined Lunkenheimer when he was 20 years old, beginning in the timekeeper's dept. He was also a director of the Central Trust Co, Cincinnati.

PROF ARTHUR E NORTON, Gordon McKay professor of applied mechanics at Harvard Graduate School of Engineering, and widely known in New England engineering circles, died suddenly at Cambridge, February 24, while going to the university. He was a member of engineering Education and Professional Development Committee of the Engineering Societies of New England. He was born in Portland, Me., in 1877, and was educated at Brown University. He had been on the staff at Harvard since 1901.

PERSONALS

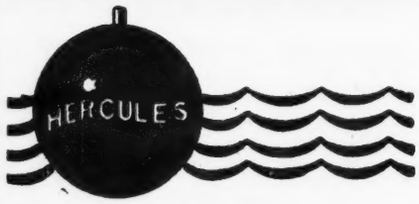
TOMLINSON FORT has been appointed assistant manager of central-station sales of the Westinghouse Electric & Mfg Co. Mr Fort, a graduate of New Mexico College of Agriculture, joined the Westinghouse Co in 1923 as a graduate student. After sales training at East Pittsburgh he was assigned to headquarters sales until 1927. He was then transferred to company's eastern district as central-station salesman with headquarters at Albany. Since 1931 he had been in the Westinghouse New York offices, but will now be located at East Pittsburgh, Pa.

J M COSGROVE, Standard Steel Spring Co, Coraopolis, Pa., has been appointed director of the company development laboratory. He will be actively interested in research on new corrosion-proof coatings. Mr Cosgrove was formerly chief chemist of Noblitt-Sparks Industries, Inc, and before that, process-control engineer for the Meaker Co and development engineer for Western Electric Co. He was graduated from Massachusetts Institute of Technology as an electrochemical engineer.

MAJ JAMES W H MYRICK, for many years a consulting engineer in heating and ventilating field at Boston, Mass., has been nominated director of the Division of Smoke Prevention of the Mass. Dept of Public Utilities. He succeeds Michael J O'Neill, who has headed that work for the past 5½ years.

H H YEAGER has been appointed assistant sales manager of Shafer Bearing Corp, Chicago. He was for a number of years district sales manager of Dodge Mfg Corp, and prior to that was manager of the Mill Supply Dept of SKF Industries, Inc.

HERCULES
Seamless Copper
FLOATS



GUARANTEED TO STAND UP!

Every Hercules Float carries our guarantee to stand up under 350 lbs. working pressure and 500 degrees temperature.

Fabricated of seamless copper under our special spinning process, Hercules Floats are uniform in thickness and high in mechanical strength.

You can depend on Hercules for floats—in standard shapes up to 10 in. and in special types to your specifications—to give long, dependable, economical service.

Insure care-free maintenance of water level in your heaters, tanks, reservoirs and other equipment by specifying "HERCULES."

HERCULES FLOAT WORKS
200 Franklin St.
SPRINGFIELD, MASS.

"STANDCO" PILLOW BLOCKS

Fig. 1635

Combining clamp block and pillow block requirements in one type, the "Standco" shown above is sturdily built and is offered in a wide range of sizes. Babbitted bearing surfaces are finished beautifully smooth. It can be depended on for long, trouble-free service.

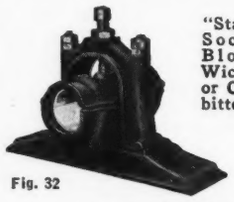


Fig. 32

"Standco" Ball and Socket Pillow Block, Ring or Wick Oiling, Plain or Collar End Babbitted Bearings.

Write for Bulletin

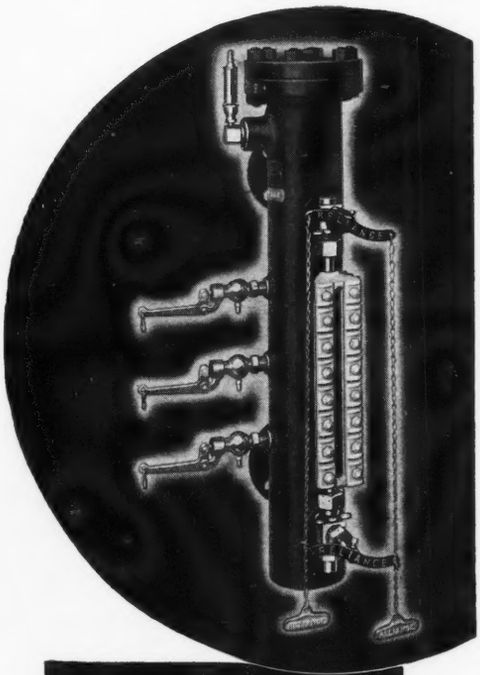
STANDARD PRESSED STEEL CO.
JENKINTOWN, PENNA.
Boston, Detroit, Indianapolis — Box 577 — Chicago, St. Louis, San Francisco

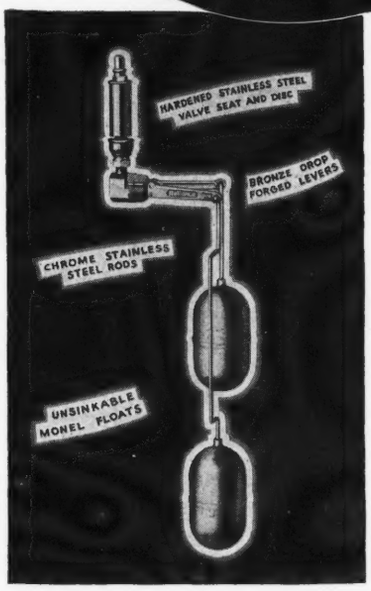
Don't Risk Costly Power Break-Downs!

★ ★

Reliance Water Level Alarms COST LITTLE...

Protect Steady Profitable Production




HARDENED STAINLESS STEEL VALVE SEAT AND DISC
BRONZE DROP FORGED LEVERS
CHROME STAINLESS STEEL RODS
UNSINKABLE MONEL FLOATS

Reliance fused monel floats are highly buoyant—guaranteed unsinkable in the service for which designed. Hundreds of thousands in use.

You find thousands of engineers who insist on having Reliance Alarms on their boilers—men who can boast of outstanding power plant operation, without time lost in shut-downs, and without fear of damage and confusion from water level accidents.

The small cost of the Alarm is no factor when weighed against losses in burned out tubes, cracked headers, bulged sheets and serious explosions.

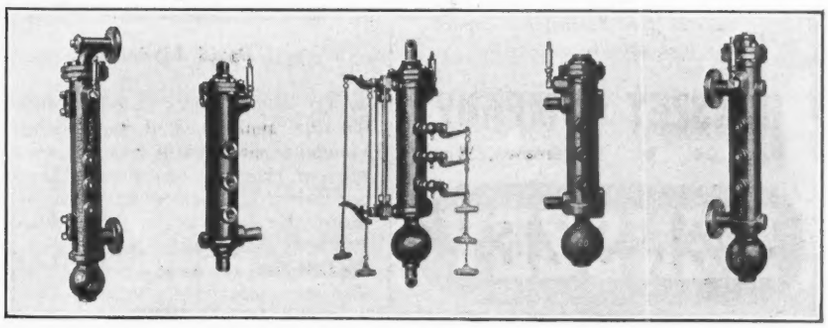
The Alarm is a reliable SOUND Check; its sensitive mechanism responds instantly to dangerously low or high water levels—warns boiler-room men by shrill whistle or electric signal.

An aggressive engineering policy keeps the Reliance Alarm in pace with modern trends in materials, steam pressures and temperatures—sturdily built to take the punishment of operating conditions.

The busier you are the more it pays you to *keep* power flowing, and protect your reputation for efficient low-cost power plant operation. Write today for information.

The Reliance Gauge Column Company
5902 Carnegie Avenue Cleveland, Ohio
Representatives in principal cities to serve you

Reliance Alarms are made for all types of boilers and all working steam pressures up to 900 lbs. Reliance Accessories include gage valves, gage cocks, Prismatic, Micasight and Flat Glass Gage Inserts.



Reliance TRADE MARK REG. IN U.S. PAT. OFF.

Boiler Safety Devices since 1884

THE RELIANCE GAUGE COLUMN CO.
5902 Carnegie Ave., Cleveland, Ohio
Please send full information about the alarm.

Name .....
Company .....
Address .....

Your BOILERS *deserve*

HENSZEY

BOILER FEED REGULATORS

The Henszey Boiler Feed Regulator is a self-contained unit needing no additional structural supports. It is as easy to install as a simple gate or globe valve.

Working on the principle of thermal expansion in a metallic tube, the Henszey Boiler Feed Regulator accurately controls the boiler water level at all loads—from the lightest to the heaviest. It offers an Everdur expansion tube with copper radiators for quick action, outboard ball bearing and grease packed stuffing box in all sizes and for all pressures. You get more for your money!

RELIABILITY **— the same as in Henszey Meters and Continuous Blowdown Systems.**

● ***Use the coupon below to get your free copy of our latest bulletin for dimensions, capacities and details.***

HENSZEY COMPANY

Dept. D4 • Watertown, Wis.

HENSZEY

HENSZEY COMPANY
Dept. D4, Watertown, Wis.

We are interested in reliable automatic boiler feed water control. Send us a Boiler Feed Regulator bulletin.

Company .....

By .....

Address .....

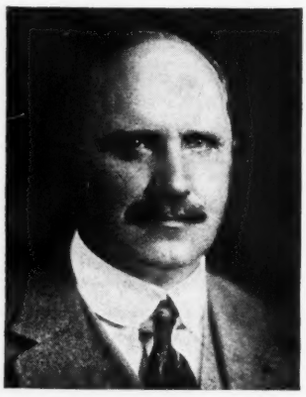
.....

CHARLES E WILSON, vice-president in charge of Pacific Coast operations, Worthington Pump & Machinery Corp, is moving his headquarters to the home office at Harrison, N. J., where he will direct sales of all products handled by Carbondale Div. He will also assume directional charge of sales of all company's products built at the Holyoke, Mass., factory.

Appointment of W J VOGEL as assistant chief engineer of Combustion Engineering Co, Inc, was announced recently. Mr Vogel entered the company in 1924, following work with Babcock & Wilcox Co. Since then he has spent four years in engineering sales work in Philadelphia and Detroit offices, and most of the remaining time as contract engineer in the Engrg Dept.

At a meeting of the Board of Directors of Foote Bros Gear & Machine Corp, WILLIAM A BARR was elected president. Upon the resignation in 1939 of former president F H Fowler, Mr Barr was elected executive vice-president and general manager. He was vice-president in charge of manufacturing for the past 8 years, having joined the company in 1929.

DAVID LINDQUIST, chief engineer, Otis Elevator Co, and long-standing member of the American Society of Swedish Engineers, was awarded the John Ericsson Medal for 1940. This medal was established in 1926 in honor of John Ericsson, that his memory might be honored by the Society which was founded one year before his death. The medal was presented to Mr Lindquist at the dinner meeting of the



David Lindquist

Society, held February 10, which celebrated the 52nd anniversary of its founding. Mr Lindquist was born in Sweden, where he received his early education, after which he received his engineering degree in Germany. He came to the United States in 1902 and shortly after took up work with the Otis company as an electrical designer. He was made chief engineer in 1911, a position he still holds. Presentation of the medal was made by Eric A Lof, chairman of the Medal Committee of the Society.

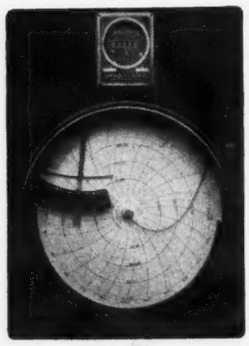
R P PROFFITT has been appointed Chicago Div manager of the Timken Roller Bearing Co. Prior to his position with Timken, he was employed at various times by American Car & Foundry Co, C & M Co, and the U. S. Government.

JOE S THOMPSON has been appointed

A SYNONYM

for – Economy
– Accuracy
– Efficiency

SIMPLEX



The selection of SIMPLEX meters for your flow measuring problems insures ECONOMIES resulting from low first cost and minimum maintenance and operating charges.

The ability of the SIMPLEX meter to measure with extreme ACCURACY over wide flow ranges insures the obtaining of a definite knowledge of all flow conditions.

Only by the complete instrumentation of all flow functions can true operating EFFICIENCIES be obtained.

There is a SIMPLEX instrument FOR YOUR specific problems.

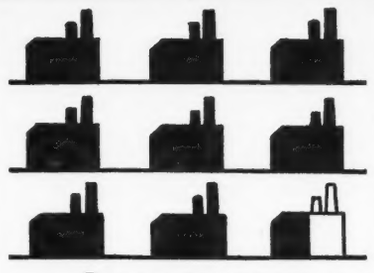
Let our engineers show you how the proper selection of your metering equipment can insure greater plant ECONOMIES and EFFICIENCIES.

Write for Data

SIMPLEX
VALVE & METER CO.
6780 Upland Street
PHILADELPHIA, PA.

NOTICE
This advertisement is one in a series which gives you the basic reasons for the present nationwide use of APEXIOR on boiler tubes and drums. The final advertisement in the series will be an evaluation in terms of dollars and cents — based upon the experiences of many industrial and utility operators.

Mechanical Protection
is Common Sense



OVER 80% OF OUR ORDERS EACH YEAR HAVE BEEN REORDERS FROM COMPANIES THAT HAVE TRIED APEXIOR AND FOUND THAT IT

KEEPS BOILERS CLEAN LONGER

MAKES BOILER CLEANING EASIER

In every boiler field — utility, industrial, railroad and marine—there is an important group of Engineers who believe that use of APEXIOR—brush-applied protective coating—is common sense in boiler maintenance.

They consider that in such mechanical surface protection against corrosion and adherent bonding of scale ... there is a simple and effective cooperation in handling the feedwater and maintenance problem.

The illustration shows the APEXIORIZED surface of a high pressure boiler drum *after one year of service.* It has just been *cleaned with a power-driven soft bristle brush.* Note the shine of the APEXIOR coating—and that it is intact over joints where the tubes have been rolled into the heavy drum plate.

To lower the cost of good boiler housekeeping and lengthen the life of boiler metal — APEXIORIZE.

WRITE FOR FREE BULLETIN 1300.

APEXIOR REG U.S. PAT. OFF.

CERTIFIED IN SERVICE BY ITS USERS

THE DAMPNEY COMPANY OF AMERICA

PROTECTIVE COATINGS FOR STATIONARY BOILERS, LOCOMOTIVES AND STEAMSHIPS

HYDE PARK · BOSTON · MASSACHUSETTS

Atlanta Chicago New York Detroit Philadelphia

Engineering Sales Representatives — Pittsburgh, San Francisco, Los Angeles, Portland, Seattle, Phoenix, Denver, Salt Lake City, Dallas, Houston, Vancouver, B.C., Montreal, P.Q., Havana, Cuba, Manila, P.I., Honolulu, T.H., Marine Dept., 114 Liberty St., New York, N.Y.

Another OAKITE IDEA to help you save!

LOW-COST WAY TO STRIP TRANSFORMERS

Important transformer paint-stripping job ahead of you? Then do it the easy . . . the successful, well-known Oakite way!

Fast . . . simple . . . doing a thorough job . . . the Oakite Hot Flow-On Method of stripping paint is amazingly low in cost. Yes . . . you can strip from 10 to 20 or more coats in one operation, removing paint right down to bare metal, in perfect condition to take priming and subsequent coats of paint. The method eliminates the need for hand chipping or scraping . . . . avoids many occupational hazards previously associated with this work.

Save Money...Save Time ON THESE JOBS, TOO!

On other jobs, too, such as removing lime scale and rust from Diesel cooling systems, cleaning "lube" oil coolers, specially designed Oakite materials help you do this work with worth-while savings in time and money. Tell us your problem . . . no obligation, of course.

OAKITE PRODUCTS, INC.
23 Thames Street, New York, N. Y.
Representatives in All Principal Cities of the United States and Canada.

OAKITE Certified cleaning
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

Chicago district sales manager of Babcock & Wilcox Tube Co, Beaver Falls, Pa. He has been with the company since 1934, and was transferred to Chicago as a salesman in 1937.

LESLIE G ESTEP has been appointed chief engineer of the United Wall Paper Factories, Inc. He will supervise and direct all mechanical development and design carried out in company's research laboratory in Chicago. He will also have charge of plant engineering and power houses for the company's other mills.

D ROBERT YARNALL, president of Yarnall-Waring Co, and THOMAS B MCCABE, president of Scott Paper Co, were appointed to the Business Advisory Council for the U. S. Department of Commerce. W L Batt, president of SKF Industries, Inc, was named chairman of the council, which meets in Washington, D. C.

JAMES H POLHEMUS, for the past 4 years executive vice-president of Portland Electric Power Co, Portland, Ore., and its affiliates, Portland General Electric Co and Portland Traction Co, has been elected president of Portland General Electric Co, to succeed Franklin T Griffith. Mr Griffith, who has been associated with the company and its affiliates for 46 years as an attorney, general counsel and president, will continue in its affairs as chairman of the board.

H A FELDBUSH has been appointed a vice-president of Worthington Pump & Machinery Corp. He will make his headquarters at Holyoke, Mass., where he will have charge of operations of the Holyoke Works. Mr. Feldbush was formerly general manager of Carbondale Div at Harrison, N. J., and in his new capacity will continue as an active member of Carbondale Operating Committee.

ROBERT W LEA, vice-president in charge of finance of Johns-Manville Corp, was elected a director recently. Mr. Lea joined the company as a vice-president in March 1939, resigning the presidency of West Virginia Coal & Coke Corp and Ohio River Co.

O H HENSCHEL, 647 W Virginia St, Milwaukee, Wis., has been appointed district representative for E Keeler Co in Wisconsin. He was formerly representative for Riley Stoker Corp, in the same territory.

DR JESSE T LITTLETON, for past 20 years head of the physics laboratory, Corning Glass Works, Corning, N. Y., has been promoted to newly-created position of assistant director of research. He has been with Corning since 1913, becoming chief of the Physics Laboratory in 1920.

ROBERT GRIMSHAW, engineer who was noted during his active lifetime for the invention of devices to aid the blind, celebrated his 90th birthday at his home in Leonia, N. J., recently. He was one of the founders of the American Society of Mechanical Engineers, has been an active member of French and German engineering societies, and was also founder of the Polytechnic Society of Greater New York.

Save Air—Save Dollars
WITH
ROCKWELL BLAST GATES

Threaded Butterfly Type

Wafer Butterfly Flanged Type

For Low Pressure Air
•
Slide Type
Butterfly Type
Wafer Butterfly Type
Kwikleen Type
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Write for catalog No. 3760
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W. S. ROCKWELL COMPANY
50 CHURCH ST., NEW YORK

Babbitt
Adjustable
SPROCKET RIM
with Chain Guide

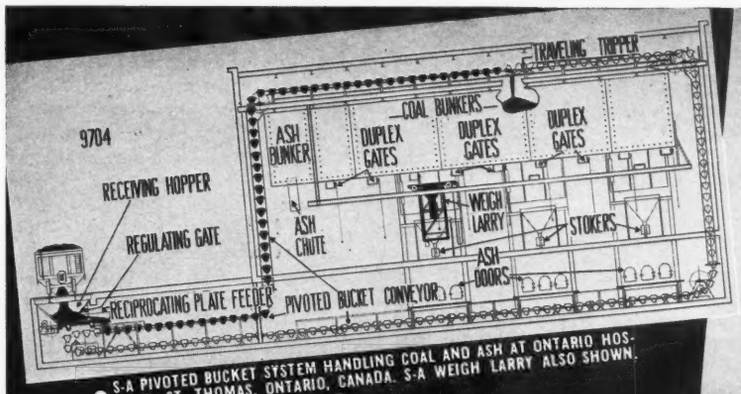
MAKE YOUR OVERHEAD VALVES SAFE and EASY TO REACH—
CONTROL VALVES FROM THE FLOOR

With Babbitt Sprocket Rims on your overhead valves, you can control valves instantly from the floor. Far quicker and safer than climbing ladders.

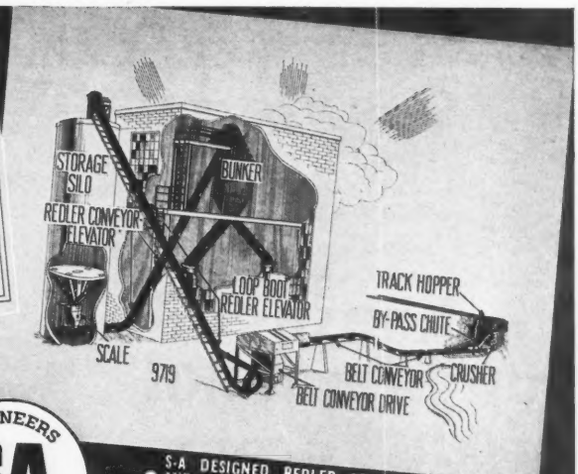
Babbitt Rims are easily attached in a few minutes, are inexpensive and assure safe, positive and instantaneous overhead valve operation. Available for valves of every make or style. Write for details.

BABBITT STEAM SPECIALTY CO.
New Bedford Mass.

S-A EQUIPMENT IS ENGINEERED TO HANDLE COAL AND ASH *at the Lowest Possible Cost Per Ton*

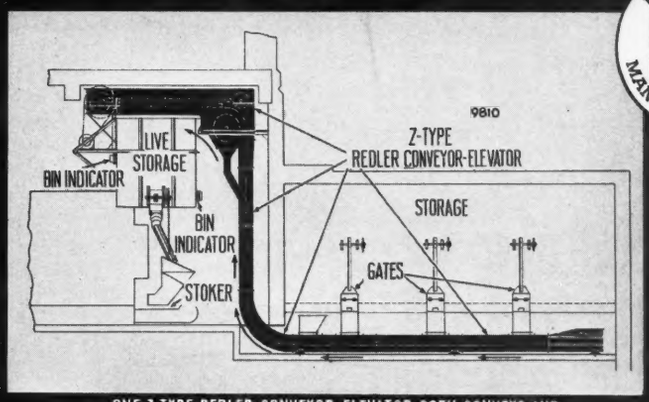


● S-A PIVOTED BUCKET SYSTEM HANDLING COAL AND ASH AT ONTARIO HOSPITAL, ST. THOMAS, ONTARIO, CANADA. S-A WEIGH LARRY ALSO SHOWN.



● S-A DESIGNED REDLER CONVEYOR-ELEVATORS AND BELT CONVEYOR AT HARTFORD CITY PAPER COMPANY, HARTFORD CITY, INDIANA.

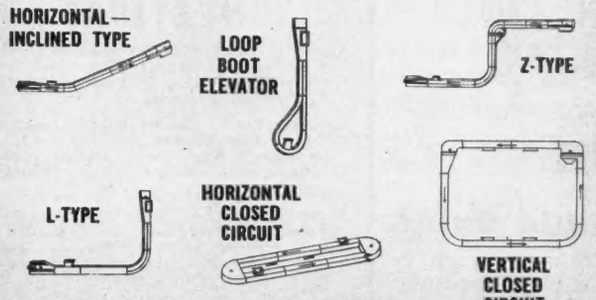
ENGINEERS **SA** MANUFACTURERS



● ONE Z-TYPE REDLER CONVEYOR-ELEVATOR BOTH CONVEYS AND ELEVATES COAL FROM STORAGE TO STOKER HOPPER AT WINNEBAGO COUNTY COURT HOUSE, OSHKOSH, WISCONSIN.

TYPICAL REDLER CONVEYOR-ELEVATOR SHAPES

Redler Conveyor-Elevators are available to convey and elevate coal and other pulverized, granular, small lump and flaky materials in any required direction. Redlers are totally enclosed, dust-tight, occupy ¼ to ½ the usual space, require no deep pits for Elevators, feed and discharge at any required point, and are self-feeding—eliminating the need for Feeders of any kind. Here are but six of numerous shapes.



LEARN FROM REDLER ENGINEERING HANDBOOK 42 HOW REDLERS CAN HELP YOU HANDLE COAL AND OTHER BULK MATERIALS ECONOMICALLY!

This valuable forty-page book explains how the self-feeding action of Redlers eliminates the expense of Feeders, how the Elevator construction eliminates boot pits, how the *en masse* conveying-elevating action moves coal and other materials cleanly and smoothly. *Write for your copy today!*

Only Stephens-Adamson can offer you your choice of Redler Conveyor-Elevators, Pivoted Bucket Conveyors, Belt Conveyors, Gravity Discharge Conveyors, Skip Hoists and Bucket Elevators . . .

Both old timers and younger engineers agree that in buying Material Handling equipment, "It's the cost per ton over the life of the equipment that counts."

One requirement may call for enclosed, dust-tight, compact Redler Conveyor-Elevators; another may call for Belt Conveyors or Gravity Discharge Conveyors; still another may call for a combination of several of these types.

Only Stephens-Adamson, pioneer manufacturers of Material Handling equipment, can offer you not only standard types of Material Handling equipment such as Belt Conveyors, Skip Hoists, Bucket Elevators and Pivoted Bucket Conveyors—but also Redler Conveyor-Elevators—for S-A is the exclusive manufacturer of Redler Conveyor-Elevators in the United States and Canada.

S-A Engineers are equipped to offer you *more* than Material Handling equipment—you will find them ready to submit money-saving ideas to show you how to handle coal and ash, or other bulk materials, at the *lowest possible cost per ton over the longest period.*

Take advantage of this S-A service for your next job.

Call on us for ideas as well as machinery—without obligation.

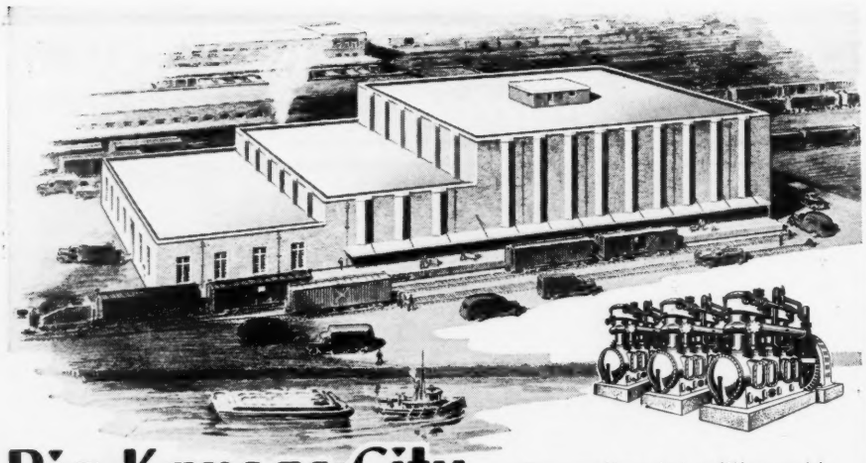
●

Conveying · Elevating · Screening · Transmission Equipment

STEPHENS-ADAMSON MFG. CO.

5 RIDGEWAY AVENUE

LOS ANGELES, CAL. AURORA, ILLINOIS BELLEVILLE, ONTARIO.



Big Kansas City Food Terminal to have

For cooling 1¼ million cubic feet of storage space, and freezing 160 tons of ice daily.

Three big Frick 4-cylinder compressors, and a large 2-cylinder Frick machine, will carry the refrigerating load. Architect is Jos. W. Radotinsky. The plant is in Kansas City, Kansas.

For that important refrigerating, ice-making, or air conditioning job of yours, get quotations from the nearest Frick Branch Office or Distributor.

TRADE FRICK MARK

FRICK CO., Waynesboro, Penna.

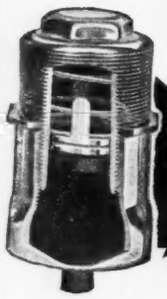
Refrigerating & Ice-making Equipment

HUNTER

"Airspring"

GREASE CUPS

Drawn-steel, cadmium plated—never known to rust.



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"Shurflo"

OIL CUPS

For service where grit, dust or lint is a problem.

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PRESSED STEEL CO.

LANSDALE, PA.

YOUR

Dependable Guide

. . . to the big things and little things done each month by operators and manufacturers across the country to raise plant efficiencies, cut costs, and reduce trouble.

It Pays You to

Read POWER Regularly

BUSINESS ITEMS

HEWITT RUBBER CORP, Buffalo, N. Y. announces appointment of Benjamin T Moffatt as New York district manager. He will be in charge of New York district sales with headquarters at the New York office.

ELLIOTT CO, Jeannette, Pa., has made several changes in personnel: V H Peterson, for past 2 years assistant to president in coordinating sales activities, has been appointed general manager of sales. W A Elliott, former Cincinnati district manager, has been made Chicago district manager. E H Haslam, who has served for 12 years as Chicago district representative, requested that he be relieved of management responsibilities, and will remain in the Chicago office as special representative. J A Gerlach is now manager of the Cincinnati district office. New additions to staff include A R Foote, in the New York office, and F S Wardwell, also in New York. H W Vancleve has joined the Philadelphia district office as sales engineer.

TIDE WATER ASSOCIATED OIL CO has set up a southern branch for distribution of its products. New office and warehouse will be at 1122 South Blvd, Charlotte, N. C. R H Mariner is new regional manager and W H Young will assist him in a sales capacity. Both have served with the company previously in other positions.

PRAT-DANIEL CORP, Port Chester, N. Y. has appointed Frank Howell Co, 318 American Bldg, Richmond, Va., as representative in that territory.

QUAKER CITY RUBBER CO, Phila, Pa. announces changes in corporate charter and corporate name. New name is Quaker Rubber Corp. No personnel, or other changes in company set-up, were made.

TIMKEN ROLLER BEARING CO has appointed M H Kuhl assistant manager of

MEETINGS

American Society of Mechanical Engineers—*Spring Meeting, May 1–3, 1940, Worcester, Mass. C E Davies, secretary, 29 W 39th St, New York, N. Y.*

Midwest Power Conference—*Palmer House Hotel, Chicago, Ill., April 9–10, 1940. Charles A Nash, secretary of 1940 conference, 4715 N Spaulding Ave, Chicago, Ill.*

National District Heating Association—*Annual Meeting, May 14–17, 1940, French Lick Springs Hotel, French Lick, Indiana. John F Collins, Jr, secretary-treasurer, 1231 Grant Bldg, Pittsburgh, Pa.*

Heating, Piping and Air Conditioning Contractors National Association—*Annual Convention, May 27–30, Hotel Pennsylvania, New York, N. Y. Joseph C Fitts, secretary, 1250 Sixth Ave, New York, N. Y.*

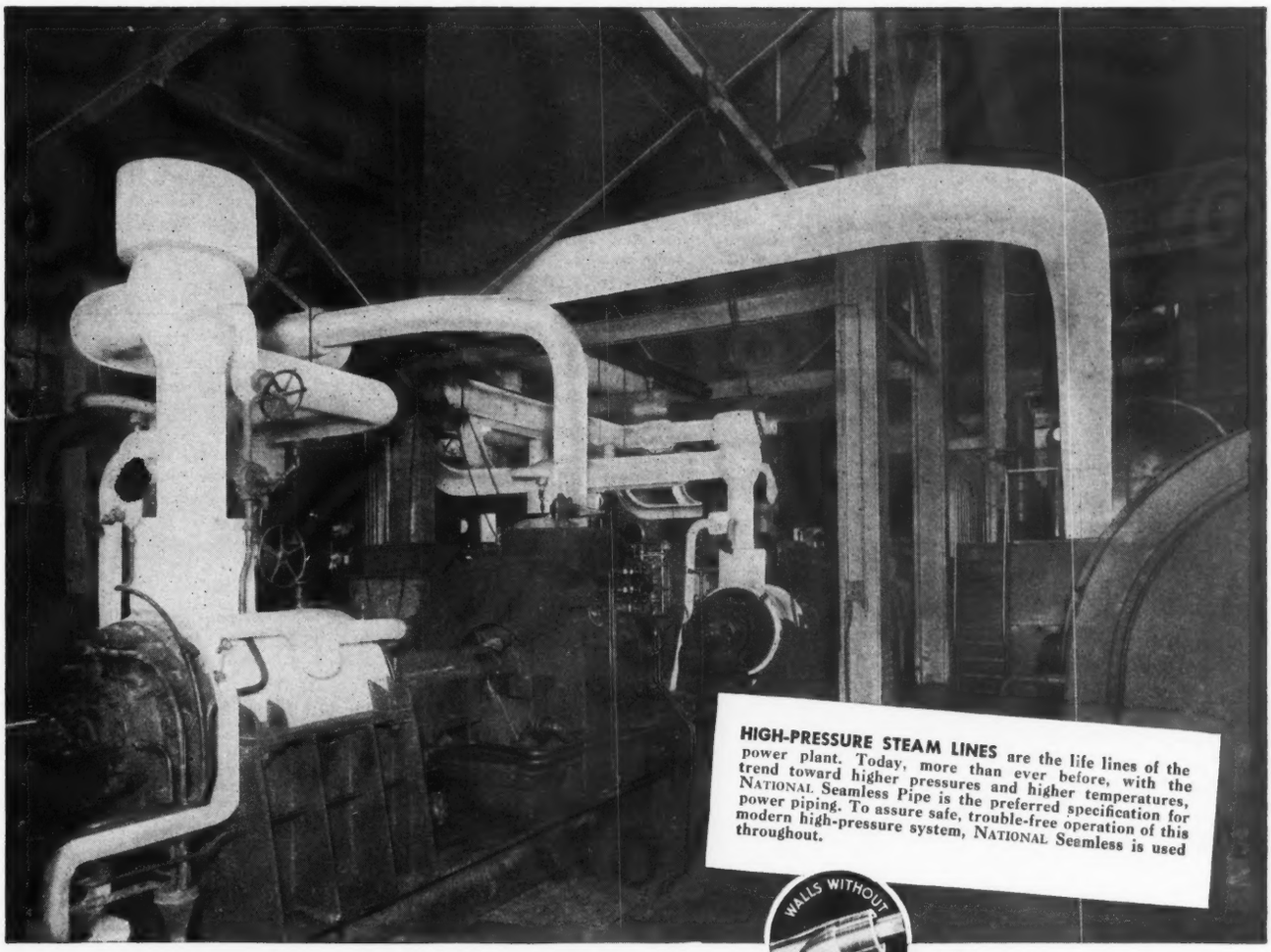
Smoke Prevention Association—*Annual Convention, May 21–24, Hotel Statler, St. Louis, Mo. Headquarters Office, City Hall Square Bldg, Chicago, Ill.*

Stoker Manufacturers Association—*Annual Meeting, June 6–7, Homestead Hotel, Hot Springs, Va. Headquarters Office, 307 N Michigan Ave, Chicago, Ill.*

International Acetylene Association—*40th Convention, April 10–11–12, 1940, Schroeder Hotel, Milwaukee, Wis. Headquarters Office, 30 East 40th St, New York, N. Y.*

"For high pressures and high temperatures

Give me SEAMLESS PIPE"


HIGH-PRESSURE STEAM LINES are the life lines of the power plant. Today, more than ever before, with the trend toward higher pressures and higher temperatures, NATIONAL Seamless Pipe is the preferred specification for power piping. To assure safe, trouble-free operation of this modern high-pressure system, NATIONAL Seamless is used throughout.
WALLS WITHOUT
WELDS

How often that's repeated!

Wherever there's talk about piping, industrial experts agree on this point —"For high pressure and high temperature service, give me NATIONAL Seamless — 'Walls Without Welds'."

Behind this nation-wide preference for NATIONAL Seamless is an abundance of proof. In steam-generating systems, processing plants, oil refineries, and heat-transfer equipment, NATIONAL Seamless Pipe and Tubes have convincingly demonstrated their ability to withstand the severest working conditions.

Why take chances when you can install safe, trouble-free piping. Standardize on NATIONAL Seamless — the pipe that's pierced from solid billets of finest quality steel. It has no weld, no line of potential weakness to limit safe operating pressures. Every length is an homogeneous, perfectly formed steel cylinder. It is made to the detailed requirements of recognized standard specifications — carefully tested and inspected. It's the finest all-round pipe modern methods can produce. Write today for complete engineering data on NATIONAL Seamless Pipe.

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Increases Fuel Economy — Avoids Smoke Nuisance

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SMOKE ALARM CUTS FUEL COSTS BY CONTROLLING SMOKE IN THOUSANDS OF POWER PLANTS.

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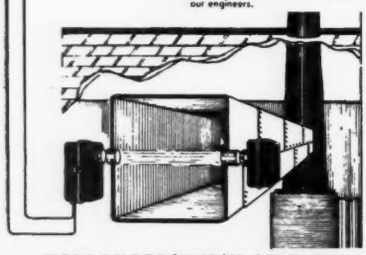

HOW PHOTOSWITCH OPERATES

Photoswitch Control and Light Source are aligned on opposite sides of the flue or breaching, the light beam projecting to the lens of the control. When the smoke passing through the flue exceeds the density at which the tamper-proof sensitivity adjustment has been set, PHOTOSWITCH flashes a signal to boiler room attendant as a warning that combustion conditions require correction.

The PHOTOSWITCH DENSOMETER shown above wired to the output of the control continuously indicates the smoke density and flashes a red signal light when smoke is excessive. Complete smoke alarm installations can be made quickly and easily by your own mechanic.

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Send detailed information on "Fuel Savings with PHOTOSWITCH."
Signed Concern
Address City State

PHOTOSWITCH INCORPORATED
CAMBRIDGE • MASSACHUSETTS
District offices in all principal cities

its Industrial Div. This position was formerly held by S D Partridge, who was promoted to manager. P J Reeves has been transferred to the home office to engage in special sales work. He was formerly manager of the Los Angeles office, which position is now being filled by S T Salvage.

JOHNS-MANVILLE Co, Manville, N. J. plant, announces that George S Smith, who has been plant engineer since 1932, has been made assistant chief engineer of General Engrg Dept. E I Merrel will succeed Mr Smith as plant engineer at Manville factory.

WORTHINGTON PUMP & MACHINERY CORP announces that its subsidiary, Moore Steam Turbine Corp, Wellsville, N. Y. has been consolidated as Moore Steam Turbine Div, of Worthington, effective in February.

MAXIM SILENCER Co announces appointment of Eliot W Higgins as special representative. Mr Higgins returns to company after a period of several years absence.

PROPELLER FAN MANUFACTURERS ASSN held its annual meeting on January 23, and elected officers. A R Stephan, DeBothezat Ventilating Equipment Co, was elected president, M W Bauer, Aerovent Fan Co, vice-president; and V C Shetler secretary-treasurer. Association offices are in General Motors Bldg, Detroit, Mich.

FALK CORP, Milwaukee, Wis., announces that Herman W Falk, founder of company and president since its inception, now becomes chairman of the board and is succeeded as president by Harold S Falk.

CUTLER-HAMMER, INC, Milwaukee, Wis., announces appointment of E K Anderson as manager of the company's branch office at Dallas, Tex. Located at 624 Santa Fe Bldg, Dallas branch office is under direct supervision of G E Booth, district manager, St. Louis, Mo.

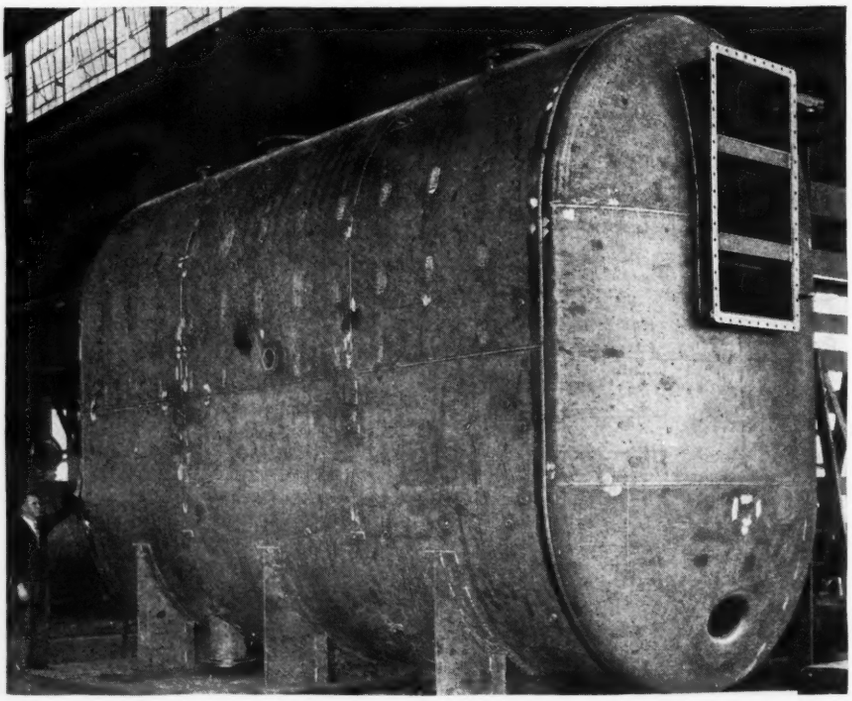
CHAIN BELT Co has announced election of J C Merwin to office of treasurer in addition to that of vice-president, which he now holds, and appointment of L B McKnight as assistant to vice-president.

DIAMOND CHAIN & MFG Co celebrates its 50th Anniversary this year. Guy A Wainwright is president, C C Winegardner, is vice-president, and Dale R Hodges is secretary and treasurer. Offices of the company are at Indianapolis, Ind.

CENTRAL TUBE Co, Pittsburgh, has announced decision to liquidate its business. Company has contracted to dispose of its plant and inventories and arrangements have been made for servicing of company's pipe stock accounts by Spang Chalfant, Inc, also of Pittsburgh.

HILLIARD CORP, Elmira, N. Y., have recently apointed Gleeson & Leahey, 339 Queen St, Ottawa, Canada, as their exclusive representatives in the sale of oil reclaimers in both marine and stationary diesel fields.

By vote of stockholders February 3, 1940 corporate name of THE WHITLOCK COIL PIPE Co was changed to THE WHITLOCK MANUFACTURING Co. Management, character and products of company will remain the same.

NOT LICENSED FOR AERIAL CRAFT

Time was when any power engineer could recognize a feedwater heater nestled away in a dark corner, and no resemblance to a small dirigible could be noted. This welded-shell Elliott deaerating heater had to be shipped in three sections to Consolidated Edison's Waterside (N.Y.) Station, where it will handle 1½ million lb. hr.